metre guns, two 37-millimetre revolving cannons, and one short Gatling. She is barkentine rigged, with a plain sail area of 4480 square feet, and has a slightly ram-shaped, cast-steel stem. The complement is 100.

The pneumatic-gun cruiser is to be armed with three of Zalinski's pneumatic dynamite guns of 10½-inch calibre, each of which is to throw a shell containing 200 pounds of high explosives for a distance of one mile, and to be capable of being discharged at least once in two minutes. The guaranteed speed is twenty knots.

Under the law of August 3, 1881, authorizing the construction of two new ships, it was provided that these should be "sea-going, double-bottomed, armored vessels of about 6000 tons displacement, designed for a speed of at least sixteen knots an hour, with engines having all necessary appliances for working under forced draft, to have a complete torpedo outfit, and be armed in the most effective manner." According to the circular issued by the Navy Department, one of these was to be an armored cruiser, with a maximum draught of twenty-two feet, and the other a battle-ship, with a draught of twenty-three feet; both were to be built of steel, with double bottoms, to have numerous water-tight compartments fitted with powerful pumping apparatus, and to be supplied throughout with perfect drainage and ventilation. A ram bow, twin screws, electric search-lights, torpedo outfit, and a protected steel-armored deck running the whole length of the ship and covering the boilers, engines, and magazines, were essentials; while high power and economy were so equally demanded that, to a maximum maintained speed of seventeen knots when fully equipped, great coal endurance and small fuel consumption were to be added. In each vessel a space sufficient for two hundred and seventy people, for provisions for three months, and for water for one month, was required. The cruiser was to have two-thirds sail-power on two or three masts, each supplied with a military top fitted to mount one or more machine guns. The armament of this ship was to include ten steel breech-loading rifles—four of 10-inch and six of 6-inch calibre—and a secondary battery of four 6-pounders, four 3-pounders, and two 1-pounders, rapid-fire, and four 47-millimetre and four 37-millimetre revolving cannons, all of the Hotchkiss pattern, together with four Gatling guns. There were to be fitted six torpedo-tubes—one bow, one stern, and two on each side, of which at least one on each side forward was to be under water. The heavy guns were to load in not less than two positions, and were to be protected by at least ten and a half inches of steel armor, properly backed; the 6-inch guns were to be fitted with shields, and all the guns were to be arranged so as to obtain the greatest horizontal and vertical fire consistent with other conditions. Any vertical armored protection at the water-line was to be at least eleven inches thick in the heaviest part, and thicker, if practicable.

The armament of the line-of-battle ship was to consist of two 12-inch and six 6-inch guns, and of a secondary battery which included four 6-inch, six 3-pounder, and two 1-pounder rapid-fire guns; of four 47-millimetre and four 37-millimetre revolving cannons, and of four Gatlings. The torpedo outfit was similar to that of the cruiser.

The plans submitted were opened on April 1st of this year, and notwithstanding the difficulties which the displacement imposed upon the other requirements, no less than thirteen designs were received from ten different competitors. The most important of these were offered by the Thames Iron Ship Buildıng Company and the Barrow Ship Building Company, of Great Britain; by A. H. Grandjean, Esq, of France; and by Chief Constructor Wilson, Naval Constructor Pook, and Lieutenant Chambers, all of the United States navy. The designs were submitted to a board, and this finally recommended the Barrow plan as best suited for the armored battle ship. So far as the armored cruiser was concerned, the Board reported as follows: "The marked differences in the essential features of the designs of armored cruisers of the Barrow Ship Building Company, Lieutenant W. I. Chambers, A. H. Grandjean, and the Thames Iron Works and Ship Building Company, prevent their classification in the order of merit. Each exhibits features which strongly commend themselves, but the Board does not consider it advisable for the government to build a vessel upon any one of these plans."

The battle-ship, though designed by one of the most distinguished marine architects in England, has not in its present form received the general approval of experts, for between it and the plan submitted by the Bureau of Construction there seem to be differences of merits which are strongly in favor of the latter. The dimensions of the new ships are as follows:

Barrow Ship.	Navy Department Ship.
Length between perpendiculars, 290 feet; on load water-line, 300 feet; extreme breadth, 64 feet 1 inch; mean draught, 22 feet 6 inches; displacement, 6300 tons.	Length between perpendiculars, 300 feet; on load water-line, 310 feet; extreme breadth, 58 feet; mean draught, 22 feet; displacement, 6600 tons.

The striking differences between these two ships are found in their relative stability and sea-going qualities. Mr. John, the designer of the Barrow ship, in a paper on "Atlantic Steamers," read before the Institution of Naval Architects July 29, 1886, made the following statements:

"This question of stability will have to be carefully watched and studied within the next few years, because there is a tendency at present towards a rapid increase in the proportion of beam to length; and as the draught of water in these large ships is limited, we must be careful that in seeking higher speeds with increased beam we do not get too much stability, and so render the vessels heavy rollers and very uncomfortable as passenger-ships. It is possible the future may see vessels of greater beam than any yet afloat in the merchant-service; but if so, it is almost inevitable that they will have to be made higher out of water in order to render them easy and comfortable at sea; but even that has its limits. Perhaps it is well to give an extreme case, and here I will make use of our old friend *The Great Eastern*. . . . Now, for the purpose of trading it is quite clear that *The Great Eastern* cannot be loaded much deeper than other ships, while her beam is half as great again; and the consequence is, her stability, as compared with our modern passenger-ships, is so excessive that she is bound to be a tremendous roller among the heavy seas in the Atlantic. Her metacentric height, when loaded, was, I believe, stated by the late Mr. Froude to be as much as 8.7 feet, which is from three to four times as much as is thought sufficient for ships in the present day, or consistent with their easy behavior at sea."

Thus Mr. John himself regards 2.9 feet to 2.2 feet as the proper metacentric height for those steamers, and it is generally considered by modern designers that from 2.5 to 3.2 feet is most suitable for this class of armored ships, and is conducive to easiness of motion in a sea-way. The value of this quality to a ship intended for sea-fighting cannot be overestimated, for upon her steadiness as a gun-platform the aim and efficiency of her guns greatly depend.

It will be noticed that this ship has exceptionally great beam, that of most ships of her class and displacement, varying from 54 to 59 feet, and judging from the sketches which have appeared, her water-line coefficient is about 0.72. From an approximate calculation based on this assumption it is found that her metacentric height will be about six feet. The water-line coefficient may possibly be a little finer than 0.72, and thus reduce the metacentric height, but if this ship is assumed to have a metacentric height of three feet, her water-line coefficient would be 0.6288, which is an *impossibility*, if her coefficient of fineness of displacement be that given in the published dimensions. Such a water-line and coefficient of fineness for 6300 tons displacement would produce a perfect rectangle for a midship section. So that, unless her dimensions are changed, she will surely be a heavy roller, and after much sea duty she will suffer such severe strains as to require frequent and costly repairs.

The battle-ship designed at the Navy Department has very different qualities, if the dimensions already published be correct. To possess a metacentric height of three feet she would require a water-line coefficient of 0.753, and a midship-section coefficient of 0.89 to 0.90, which is a good proportion for such a vessel. Not only in sea-going qualities does the American design seem to be superior, but her battery is far more powerful and better disposed in every way, while her speed and endurance are equally as great as the plan recommended. Mr. John has adopted the *echelon* arrangement of heavy guns, a disposition which both the English and Italian governments have, after long trial, discarded in their latest ships. When the first sketches of a design are made, this arrangement of guns is theoretically perfect, as it is supposed to give quite as much power of fire ahead and astern as on each broadside; but when the design is developed and practically tested, it is found that too much of the ship's efficiency in other respects is sacrificed, that the powerful end fire is not attained, and that the broadside is greatly weakened, owing to the obstructed arcs of fire.

Besides this, the guns, being placed at some distance from the midship line, have less accurate fire in rolling, and the ship's propensities to roll are encouraged and are greater than would be the case if the guns were placed on the midship line. It is also found that the blast from the heavy guns is destructive to superstructures and other fittings on the upper deck. The Italians, indeed, have placed stout ventilating shafts on their *Italia* and *Lepanto* to prevent the rearmost pair of heavy guns from being trained within twenty degrees of the fore and aft line. This is done so that the blast from these guns will not prostrate the gunners attending the other pair, notwithstanding the fact that those men are under the armor cover. The *Duilio's* forward smoke-pipe is placed entirely on the port side of the fore and aft line, in order to permit of one pair of turret guns firing ahead. The upper-deck, 6-inch, central-pivot guns of the *Andrea Doria* class are now to be placed wholly within the superstructure, in order to be out of danger from the blast of the heavy guns when the latter are fired near the line of keel, and the same change would have to be made with the upper-deck, 6-inch guns in the Barrow design.

Similar objections exist to the Bureau of Construction design for an armored cruiser. This vessel, although possessing the bad features inherent in the *echelon* arrangement of heavy guns, does not have the best ideas of the Barrow design, *i. e.*, high freeboard, heavy guns mounted high above the water-line, and commodious quarters for officers and men. Both designs besides have the very objectionable and old-fashioned features of requiring the turrets to be revolved to fixed loading positions after being fired. The Bureau cruiser, it may be said, is not saddled with too much metacentric height. She has ten feet less beam, her centre of gravity is about one foot lower, and unless her water-line coefficient is very full, she will have a metacentric height rather less than what is regarded to be the best.

It is not surprising, however, that the Bureau plans are so different in efficiency, for while the better plan, the battle-ship, is original with the Navy Department, the armored cruiser is a copy of, and no substantial improvement over, that of the Brazilian ship *Riachuelo* designed several years ago. This ship is considered one of the best of her date, but great improvements in ship design have been made within the past few years, and it is against the tendencies of American inventive genius to take a step backward.

The general plans of cruisers No. 4 and 5 were published in the *New York Herald* of June 1st, together with the following data:

"They are to be twin-screw cruisers, 310 feet long on the water-line, 49 feet 1¾ inches extreme breadth, 18 feet 9 inches mean draught, displacing 4083 tons. They are to have machinery of 10,500 indicated horse-power under forced draft. The maximum speed is 19 knots, rig that of a three-masted schooner, spreading 5400 square feet of sail. They will have a double bottom extending through 129 feet of the length. The framing in this portion is on the bracket system. Before and abaft the double bottom, above the protective deck, Z-bars form the transverse frames. The protective deck, which is nineteen inches above the water-line amidships, is flat across the top, with sides which slope down to a depth of four feet three inches below the water-line. The horizontal portion is two inches thick, the slope being three inches, reduced at both ends to one and a half inches. It extends uninterruptedly forward and aft, and protects the machinery, magazines, and steering-gear, the machinery being further defended by the disposition of the coal-bunkers. The main hatches in this deck are protected by armor-bars, and have coffer-dams extending to the upper deck. The guns are carried on the gun, forecastle, and poop decks.

"*Armament.*—The main battery, which consists of twelve 6-inch breech-loading rifles, all on centre-pivot mounts, with two-inch segmental steel shields, is arranged on sponsons so as to obtain the greatest possible arc of fire. The forecastle, the poop, and the bridges have been as much as possible availed of to shelter the guns. The two guns forward and the two guns aft converge their fire a short distance from the ends of the ship, and the broadside can be concentrated within 100 feet of the side. Four above-water torpedo-tubes are provided on the berth-deck, and two direct ahead under-water torpedoes in the bow. The secondary battery is composed of four 47-millimetre revolvers, four 57-millimetre single-shots, two 37-millimetre revolvers, and one short Gatling. The coal capacity is 850 tons. The complement of men 300. . . .

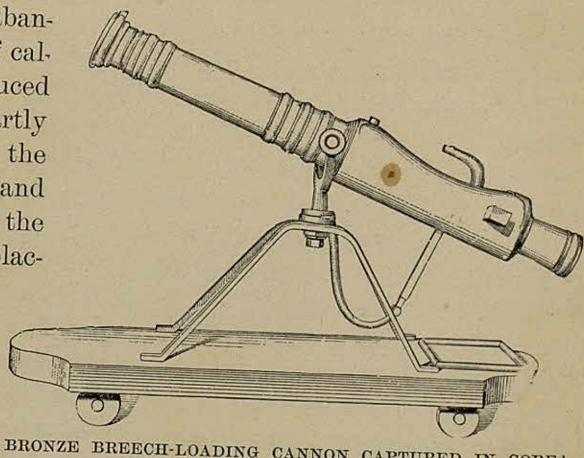
"To appreciate what is required to make nineteen knots an hour at sea, we have only to remember that the *Umbria* and *Etruria* are 500 feet long, with more than 12,000 tons displacement and 14,500 indicated horse-power, ordinarily making 18½ and on special occasions 19 knots an hour. Now, to increase her speed to 20 knots an hour, the *Umbria* would require about 19,500 horse-power, which means 5000 extra horse-power for the extra knot. For a second extra knot would be required about 6000 horse-power more, making about 25,000 horse-power necessary to develop a speed of 21 knots."

Gun-boats Nos. 3 and 4 are to be copies of gun-boat No. 1. No designs for the floating batteries and the torpedo-boat have been published. The *Stiletto* is one of the famous Herreshoff boats, and is now being tested in consequence of a favorable report made by a board of officers. On July 23, 1886, with a total displacement of twenty-eight tons, she made an average of 22.12 knots as the mean of four runs over the measured mile in a rough sea and fresh wind, and on July 30th she attained an average of 22.89 knots. These were excellent results for a boat ninety feet in length, and promised that the type, with certain modifications, was equal to greater demands. The trial data of this year have not yet been published, though it is unofficially reported that her performance was equally as creditable.

13

UNITED STATES NAVAL ARTILLERY.

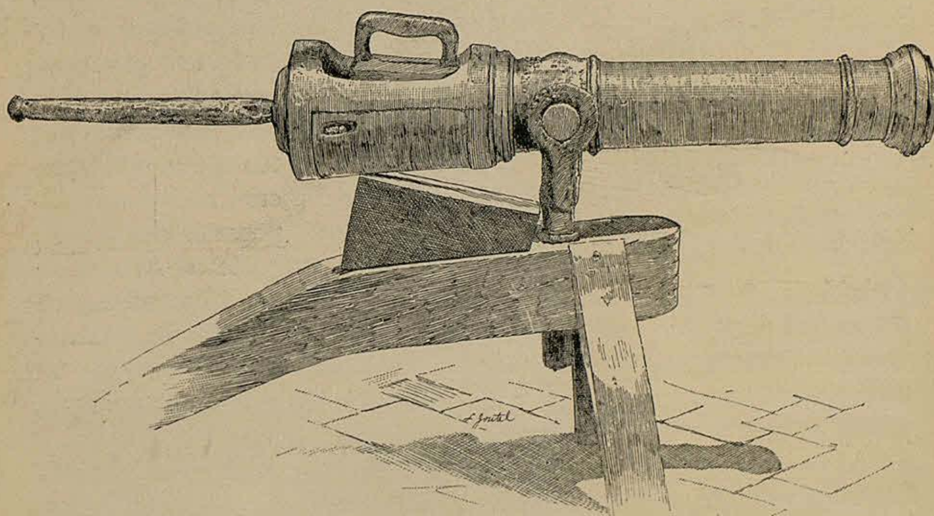
FROM the time of the introduction of cast-iron cannons in 1558 until a comparatively late period, development in naval artillery proceeded at a very slow rate. The security that was attained by the adoption of cast-iron was so great, as compared with the danger attending the use of the more ancient artillery, that the new guns were regarded as fully supplying all the demands of a suitable battery. The guns were muzzle-loaders, making the manipulation simple, the previous rude attempts at breech-loading being abandoned. The number of calibres that were introduced was very numerous, partly to suit the weight of the batteries to the ships, and partly to accommodate the fancy of the time for placing in different parts of the ships guns varying much in size and destructive effect. The general character of the batteries and the multiplication of calibres can best be illustrated by noting the armament of two typical ships of the seventeenth century.



BRONZE BREECH-LOADING CANNON CAPTURED IN COREA, AGE UNKNOWN.

The *Royal Prince*, a British ship built in 1610, carried fifty-five guns. Of these, two were *cannon-petronel*, or 24-pounders; six were *demi-cannon*, medium 32-pounders; twelve were *culverins*, 18-pounders, which were nine feet long; eighteen were *demi-culverins*, nine-pounders; thirteen were *rakers*, 5-pounders, six feet long; and four were *port-pieces*, probably swivels. These guns were disposed as follows: on the lower gun-deck, two 24-pounders, six medium 32-pounders, and twelve 18-pounders; on the upper gun-deck the battery was entirely of 9-pounders; and the forecastle and quarter-deck were armed with 5-pounders, and the brood of smaller pieces which swelled the nominal armament.

The *Sovereign of the Seas*, built in 1637, in the reign of Charles I., was unequalled by any ship afloat in her time. She mounted on three gun-decks eighty-six guns. On the lower deck were thirty long 24-pounders and medium 32-pounders; on her middle deck, thirty 12-pounders and 9-pounders; on the upper gun-deck, "other lighter ordnance;" and on her quarter-deck and forecastle, "numbers of murdering pieces."

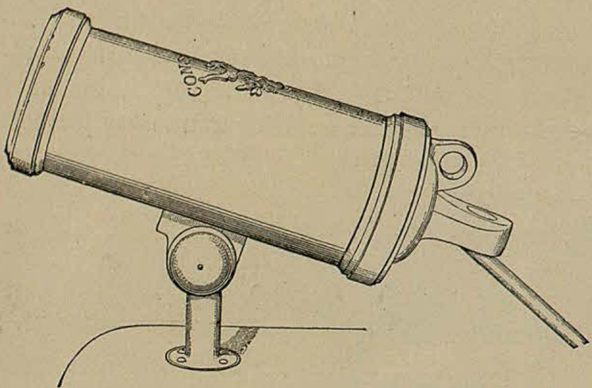


BRONZE BREECH-LOADER USED BY CORTEZ IN MEXICO.

In the obstinately contested actions between Blake and Van Tromp in the Cromwellian time, the ships and batteries did not differ in any great degree from those contemporaneous in construction with the *Sovereign of the Seas;* and when we remember the inferior character of the powder used in those days we can account for the duration of some of the engagements between the English and Dutch ships which were sometimes protracted through three days.

The brood of "murdering pieces" of small calibre and little energy was, after many years, dispersed by the introduction of carronades—a short cannon of large calibre, which was found to be a convenient substitute for the 8-pounders and 9-pounders on upper decks, and for the "lighter ordnance," which was ineffective; but this change was brought about slowly, as is seen by referring to the batteries of some ships which fought at Trafalgar.

The Spanish seventy-fours in that action had fifty-eight long 24-pounders on the gun-decks; on the spar-deck, ten iron 36-pounder carronades and four long 8-pounders; and on the poop, six iron 24-pounder carronades — total, seventy-eight guns.

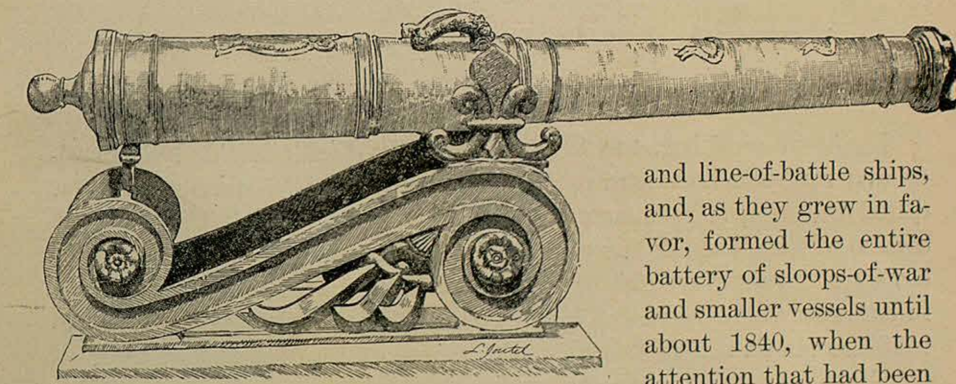

BREECH-LOADER CAPTURED IN THE WAR WITH MEXICO.

The *Victory*, the English flag-ship, mounted on her three gun-decks ninety long 32, 24, and 12 pounders, and on the quarter-deck and forecastle, ten long 12-pounders and two 68-pounder carronades. The *Santissima Trinidada* mounted on the lower gun-deck thirty long 36-pounders; on the second deck, thirty-two long 18-pounders; on the third deck thirty-two long 12-pounders; and on the spar-deck, thirty-two 8-pounders. In the British accounts she is said to have had one hundred and forty guns, which number must have included swivels mounted for the occasion.

At the end of the eighteenth century the 18-pounder was the preferred gun for the main-deck batteries of frigates, guns of larger calibre being found only on the lower decks of line-of-battle ships. The 18-pounder was the maximum calibre that was employed on board the ships of the United Colonies of North America in the war of the Revolution. The resources of the colonies did not admit of building ships to contend with vessels fit to take their place in line of battle, but such as were constructed were well adapted to resist the small British cruisers, and to capture transports and store-ships. The so-called frigates of that day were vessels varying from six hundred to a thousand tons, and, according to their capacity, carried 12-pounders or 18-pounders in the main-deck batteries. There was usually no spar-deck, but the forecastle and quarter-deck, which were connected by gangways with gratings over the intermediate space, were provided with an armament of light 6, 9, or 12 pounders. A few carronades came into use during this war.

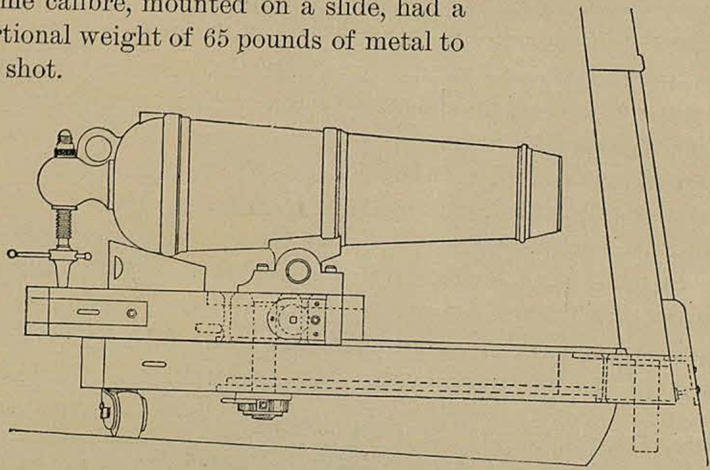
At the conclusion of this war the Colonial fleet disappeared, and it was not until the time of the depredations on the growing commerce of the United States by the Algerine corsairs that Congress felt justified in incurring the expense of establishing a national marine. The ships which were built under the law of 1794 were fully up to the most advanced ideas of the time, and some of these ships carried on their gun-decks a full battery of 24-pounders, thirty in number, while the others were armed with 18-pounders on the gun-deck, with spar-deck batteries of 9 and 12 pounders, the carronade not having been yet definitely adopted for spar-deck batteries.

It is not until the war of 1812 that we find the carronade fully established as the spar-deck armament of frigates. The *Constitution* and the *Guerrière* carried 32-pounder carronades of very similar weight and power in the place of the long guns of smaller calibre on the spar-deck. The original name of this piece of ordnance was the "Smasher," the leading purpose of the inventor, General Melville, of the British artillery, being to fire 68-pounder shot with a low charge, thus effecting a greater destruction in a ship's timbers by the increased splintering which this practice was known to produce. Carronades of small calibre were subsequently cast, which were adopted for spar-deck batteries of frigates and line-of-battle ships, and, as they grew in favor, formed the entire battery of sloops-of-war and smaller vessels until about 1840, when the attention that had been given for some years to the subject of naval ordnance began to assume tangible shape, and the effort was made to proceed in this matter in accordance with an intelligent system.



BRONZE 12-POUNDER, "EL NEPTUNO," 1781.

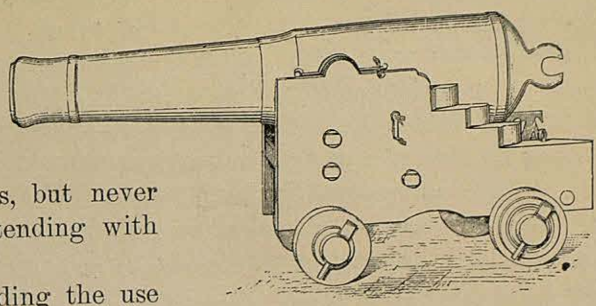
The advantage of large calibre was firmly impressed upon those who occupied themselves with the ordnance matters of the navy. As the fleet was developed, the 24-pounder gave way to the 32-pounder, and for the lower-deck battery of line-of-battle ships the 42-pounder was introduced. Some 42-pounder carronades were also introduced as spar-deck batteries for these larger ships. With the disappearance of this class of ship the 42-pounder was abandoned, and the 32-pounder was retained as the maximum calibre, different classes being assigned to different sizes of ships. These classes were divided into the gun proper, with 150 pounds of metal to one of shot; the double-fortified gun, with 200 pounds of metal to one of shot; and the medium gun, with 100 pounds of metal to one of shot. The carronade of the same calibre, mounted on a slide, had a proportional weight of 65 pounds of metal to one of shot.



U. S. N. CARRONADE, SLIDE, AND CARRIAGE.

In the interval between 1840 and 1845 the double-fortified 32-pounder was replaced by a gun of the same calibre of 57 hundred-weight, called the long 32-pounder; and to suit the capacity of the different classes of ships then in the service, there were introduced the 32-pounders of 46 hundred-weight, 42 hundred-weight, and 27 hundred-weight, in addition to the regular medium gun of 32 hundred-weight. This period also marks the introduction of shell guns as part of the battery.

To this time no explosive projectiles had been used with cannons properly so called; their use had been limited to mortars and howitzers. The mortar was originally used for projecting huge balls of stone at high angles. The first practical use made of them for projecting bombs was in 1624, but the unwieldy weight of the mortar and its bomb, the latter sometimes exceeding 300 pounds, prevented their use in field operations. To provide for this, light mortars were cast, which, being mounted on wheels, were denominated howitzers. Frederick the Great of Prussia brought this form of artillery to its highest development for field and siege use, and the Continental powers of Europe adopted it to a large extent for projecting bombs at high angles of fire. The mortar has never had a place in regular naval armaments; it has been used afloat for bombardment of cities and fortified positions, but never with a view to contending with ships.



U. S. N. MEDIUM 32-POUNDER.

The success attending the use of explosive projectiles at high elevations did not lead at once to their application to horizontal firing from cannons. An important link in the progress of the idea resulted from the effort to avail of the advantage of ricochet firing with bombs. In order to effect this, the angle of elevation had to be reduced to enable the bomb to roll along the ground. The reduced angle of elevation was still greater than that used for cannon, but the success of the experiment led to the casting by the French of an 8-inch siege howitzer, which, in connection with the development in the manufacture of fuses, made it practicable to apply the idea of firing shells, like shot, horizontally, and the chief object in view seems to have been to operate against ships.

The combining of the elements necessary for the achievement of this important step in naval artillery is by common consent credited to General Paixhan, of the French artillery, who, though not claiming the invention of any of the numerous details involved in the system, succeeded in so judiciously arranging the parts as to make the system practicable by which the whole character of naval armaments was revolutionized.

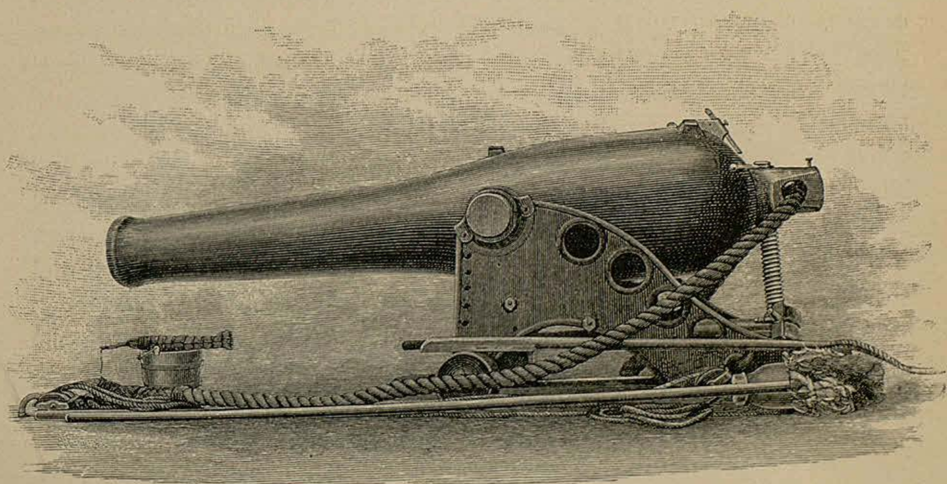
Following the progressive ideas of the age, shell-guns were introduced in the United States navy. These were of 8-inch calibre, and of weights of 63 hundred-weight and 55 hundred-weight. The guns were shaped in accordance with the form adopted by General Paixhan, and were easily distinguishable in the battery from the ordinary shot-gun. From this circumstance they obtained the title of Paixhan-guns, though there was nothing special in the gun itself to merit an appellation. The whole system was Paixhan's; the gun was only a part of the system.

It required many years to bring the shell-gun into such general application as to displace the solid-shot gun. They were assigned tentatively to ships in commission, and in 1853, by a navy regulation, the battery of a frigate was provided with only ten of these guns, which were collected in one division on the gun-deck. The first vessel in the United States navy whose battery was composed exclusively of shell-guns was the sloop-of-war *Portsmouth*, in 1856. This vessel carried a battery of sixteen 8-inch shell-guns of 63 hundred-weight. These were among the first of a new pattern of gun for which the navy is indebted to the skill and study of the late Rear-admiral Dahlgren.

The determination of the best form for cannons was a question which had occupied the minds of artillerists for some years. In the older guns the thickness of metal was badly distributed; it was too uniformly extended along the entire length, not arranged in such proportions as to accord with the differing strains along the bore. Colonel Bumford, of the United States Ordnance, had been among the first to consider this subject, and for many years the results of his experiments had guided construction to a great degree. General Paixhan made a further step in advance by reducing very much the thickness of metal along the chase of his guns, but it remained for Rear-admiral Dahlgren to produce the perfection of form in the gun so widely known bearing his name. In this gun the thickness of metal is proportioned to the effort of the gases in the bore, and all projections and angular changes of form are suppressed, giving to all parts a curved and rounded surface. The suppression of angular formations on the exterior of a casting has a remarkable effect on the arrangement of the crystals while cooling. These arrange themselves normal to the cooling waves, which, if entering from directions not radial with the cylindrical casting, produce confusion in their arrangement, establishing planes of weakness where the waves meet, which, in case of overstrain on the piece, assist rupture and determine the course of the fracture.

With the introduction of the Dahlgren shell-gun the transition of the artillery of the United States navy may be said to have been completed. The shell-gun of 9-inch and 11-inch calibres followed the 8-inch, and ships were armed with such as were appropriate to their capacity as rapidly as the new guns could be manufactured. When fully equipped, the armament of the United States navy was superior to that of any other navy in the world.

The substitution of shells for solid shot marks an important epoch in naval artillery. The probable effect of a shot could be predetermined and provided for; that of a shell was unknown. In order to produce serious injury with a shot, it was necessary to perforate the side of an enemy. This was not indispensable with a shell; with the latter, perforation might be dispensed with, as penetration to such a depth as would give efficacy to the explosion might prove more destructive to the hull than would absolute perforation. With the shot, damage was done to life and material in detail; with the shell, if successfully applied, destruction was threatened to the entire fabric, with all it contained. Naval artillery entered a new phase; the rough appliances of the past would no longer answer all demands. The founder could not alone equip the battery; the laboratory was called into use, and pressed to provide from its devices. The "new arm" depended upon the successful working of the fuse of the shell, without which it was but a hollow substitute for a solid shot, and this detail demanded the utmost care in preparation. It was the perfecting of this device which, more than aught else, delayed the general adoption of the new artillery for so long a time after its advantages had been recognized.



U. S. N. 9-INCH DAHLGREN (9-INCH SMOOTH-BORE).

The fuses that were used to explode the ancient bombs were long wooden plugs, bored cylindrically, and filled with powder condensed by tamping it to a hard consistency. The fuse case projected from the bomb, and to avoid being bent by the shock of discharge, was placed carefully in the axis of fire. Before the discharge of the mortar the fuse was lighted by a match. In applying the fuse to shell-guns fired horizontally, the problem was so to arrange it as to ignite it by the flame of discharge, and so to support it in the wall of the shell as to prevent any dislocation of the fuse composition, the cracking of which would permit the penetration of the flame into the mass. This was successfully accomplished, and the United States navy fuse was justly famous, one feature of it being a simple but most effective device called a "water-cap," which guarded against the injurious introduction of sand or water when the shell was fired *en ricochet.* The introduction of a safety-plug in the bottom of the fuse case, which required the shock of discharge to displace it in order to open a way of communication between the fuse and the bursting charge in the shell, and the absence of all accidents in manipulation, inspired such confidence that the new arm advanced to favor, and both officers and men were proud to be identified with it.

Previous to the introduction of shells there had been in use incendiary projectiles, not explosive, but intended to set fire to an enemy's vessel. Hot shot were applied to this purpose, but the use of these was chiefly confined to shore batteries, where a suitable heating furnace could be conveniently provided. The projectile for this purpose chiefly used from ships was the carcass, which was a shot in which several radial cylindrical holes were formed which were filled with powder tamped to a hard consistency; these columns of composition were ignited by the flame of discharge, and continued to burn until consumed. The flame issuing from these holes served to ignite consumable material in their vicinity. The chief danger from a carcass was from lodgment in the side of a ship; if it landed on deck it could be removed and thrown overboard, as there was no danger from explosion; the addition of the bursting charge in the cavity of a shell produced a projectile which was far in advance both for generating a flame and for preventing interference with its mission.

The probable destructive effect of shells exploding in the sides or on the open decks of ships was thoroughly recognized, and experiments at targets sufficiently proved it; but circumstances on a proving-ground and in action are so dissimilar that the experience of a naval engagement was looked forward to with much interest, in order to satisfy as to the effect of the new projectile in all the varying conditions of a sea-fight. Referring to the history of the past thirty years, which marks the period of the general introduction of shell-guns, it is remarkable how few engagements between ships have taken place; but on every occasion of the use of shells, when unarmored vessels were engaged, the effect has been most decided and complete. Three instances only can be referred to of purely sea-fights, *viz.*, the engagement between the Russian and Turkish fleets at Sinope in 1853, during the Crimean war, the engagement between the United States steamer *Hatteras* and the Confederate cruiser *Alabama* during the war of the rebellion, and the fight between the *Kearsarge* and the *Alabama* during the same war. In the affair at Sinope the Russian ships used shells; the Turkish had only solid shot. The result was the total destruction of the Turkish force. Not one ship escaped; all were burned or sunk. The fight between the *Alabama* and the *Hatteras* resulted in the sinking of the *Hatteras;* and the contest between the *Alabama* and the *Kearsarge* ended the career of the *Alabama.* And it may be noticed that but for the failure to explode of a shell that was embedded in the stern-post of the *Kearsarge*, that vessel might have accompanied her antagonist to the bottom of the sea.

The gallant attempt of Rear-admiral Lyons with the British wooden fleet before the forts of Sebastopol is an instance which proved the uselessness of subjecting unarmored vessels to the steady fire of fortified positions using shells from their batteries.

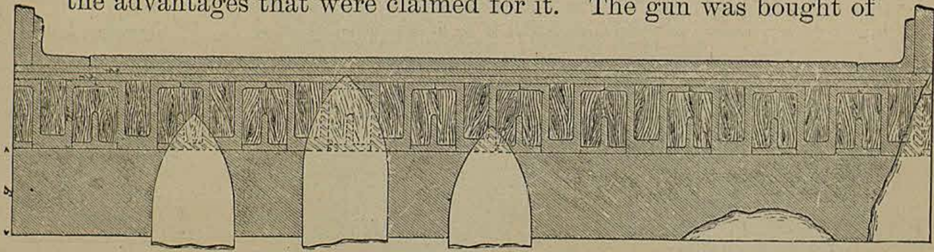
One other instance of a sea-fight can be cited in the engagement in 1879 between two Chilian armored vessels and the lightly armored Peruvian turreted vessel *Huascar.* The *Huascar* was terribly overmatched during this fight, but at its conclusion her boilers and engines were intact, and indentations on her sides showed that her light armor had deflected a number of projectiles; but the effect of the shells that had burst on board of her was apparent in the great destruction of life.

The very decisive engagement which took place at Lissa in 1866, between the Austrian and Italian fleets, should not be omitted in alluding to sea-fights of a late period; but this action can hardly be quoted as one in which the element of shell-fire can be recognized as the exclusive cause of destruction, for the remarkable impetuosity and dash of the attack and the desperate use of the ram produced a crisis which obviated the necessity for continuous bombardment with cannon.

The necessity of providing a defence against shells was recognized both by England and France during the Crimean war, and a protection of armor was supplied to some floating batteries built at that time which were intended to operate before fortified positions; and at the conclusion of the war the English built the *Warrior* and the French built *La Gloire.* These were the first specimens of iron-clad ships of war. They were capable of resisting successfully the entrance of shells from guns of the period. It is thus seen that almost coincident with the general adoption of horizontal shell-firing, naval construction entered a new phase, and a new problem was submitted to the naval artillerist.

Against an iron-faced target the solid shot might be partially effective, but the impact of the spherical shell was harmless, and the explosive effect of the bursting charge enclosed in it would be superficial. This was amply demonstrated in actual practice during our war experience, notably at Mobile Bar, in the engagement with the Confederate iron-clad *Tennessee*, the roughly constructed armor of which vessel resisted a storm of our heaviest shells.

The impotency of the spherical shell against armor being recognized by foreign governments, they proceeded to develop the rifled cannon, which with its elongated projectile offered the means of effecting the object of the time—to perforate armor with an explosive projectile. Our authorities, however, persevered in their faith in the smooth-bore, and held that the *racking* effect of a spherical projectile of sufficiently large calibre was superior to that produced by the perforation of a rifle projectile of inferior diameter. The 15-inch and 20-inch smooth-bore cannons were cast in accordance with this idea, and the racking side of the question was so obstinately held that the British government imported in 1867 from the United States a 15-inch gun for the purpose of determining by their own experiments what foundation there was for the advantages that were claimed for it. The gun was bought of



HORIZONTAL SECTION OF MILLWALL SHIELD.

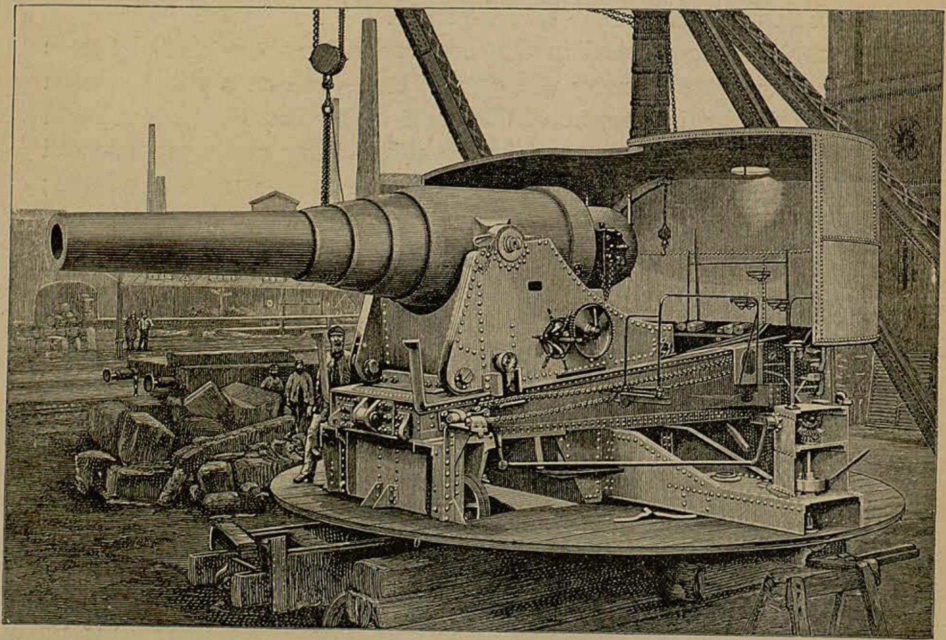
Charles Alger & Co., of Boston; it weighed nineteen tons, and threw a cast-iron spherical solid shot of about four hundred and fifty pounds. It was mounted at Shoeburyness, and was fired in competition with English rifled cannons of 9-inch and 10-inch calibres. The result of the experiments went to show that against a target with a power of resistance inferior to the energy of the projectile the effect of the large sphere at short range is more disastrous than that of the elongated rifle projectile of the same weight; but that against a target able to resist the total energy of both the injury done by the rifle projectile is by far the greater. The comparative effect is well shown on a target called the "Millwall Shield," consisting of a plate nine inches in thickness, backed by Hughes's hollow stringers—an arrangement of target which to the time of the experiment had proved invincible. The 15-inch smooth-bore spherical shot rebounded from the target six feet, leaving a 3-inch indentation on the plate, while the 9-inch rifle projectile, weighing two hundred and fifty pounds, made complete penetration of the plate, passing two or three inches into the backing, and the 10-inch rifle projectile, weighing four hundred pounds, penetrated to the rear of the backing itself.

It should be mentioned in this connection that the United States government adopted during the war of the rebellion a rifled cannon proposed by Captain Parrott of the West Point Foundery, New York, of which many were introduced into both the navy and army, and did good service as long as the charges of powder were limited in weight; but when these guns were called upon for work requiring great endurance, they proved untrustworthy and dangerous to those who served them. At the naval bombardment of Fort Fisher several of them burst, causing loss of life on board the vessels of which they formed the armament. They were constructed of cast-iron, having a coiled hoop of wrought-iron shrunk around the breech. They have ceased to form a part of our naval armament.

During the years of inaction in the United States that have intervened since these experiments, the smooth-bore partisans have had time to reflect and to learn lessons of practical usefulness from observing what has been transpiring abroad. Opportunities have been afforded to note the progress made in armor and artillery, and though the smooth-bore shell is still operative against unarmored vessels, the advantages of the rifled gun under all the circumstances of navy experiences have been admitted, and in the transition through which our naval artillery is now passing we are not embarrassed by the presentation of views antagonistic to the principles on which it has been determined our new artillery is to be constructed. The system at the basis of our present acts is founded on a comprehensive view of the whole subject, and is intended to provide our ships with a surplus of offensive power over what their capacity for defence might seem to call for.

Our navy will possess a certain number of armored vessels for coast defence, and armored sea-cruisers are certain to be included in the list, but the more numerous class will be unarmored, and the first problem to be solved is that of providing for these a suitable armament.

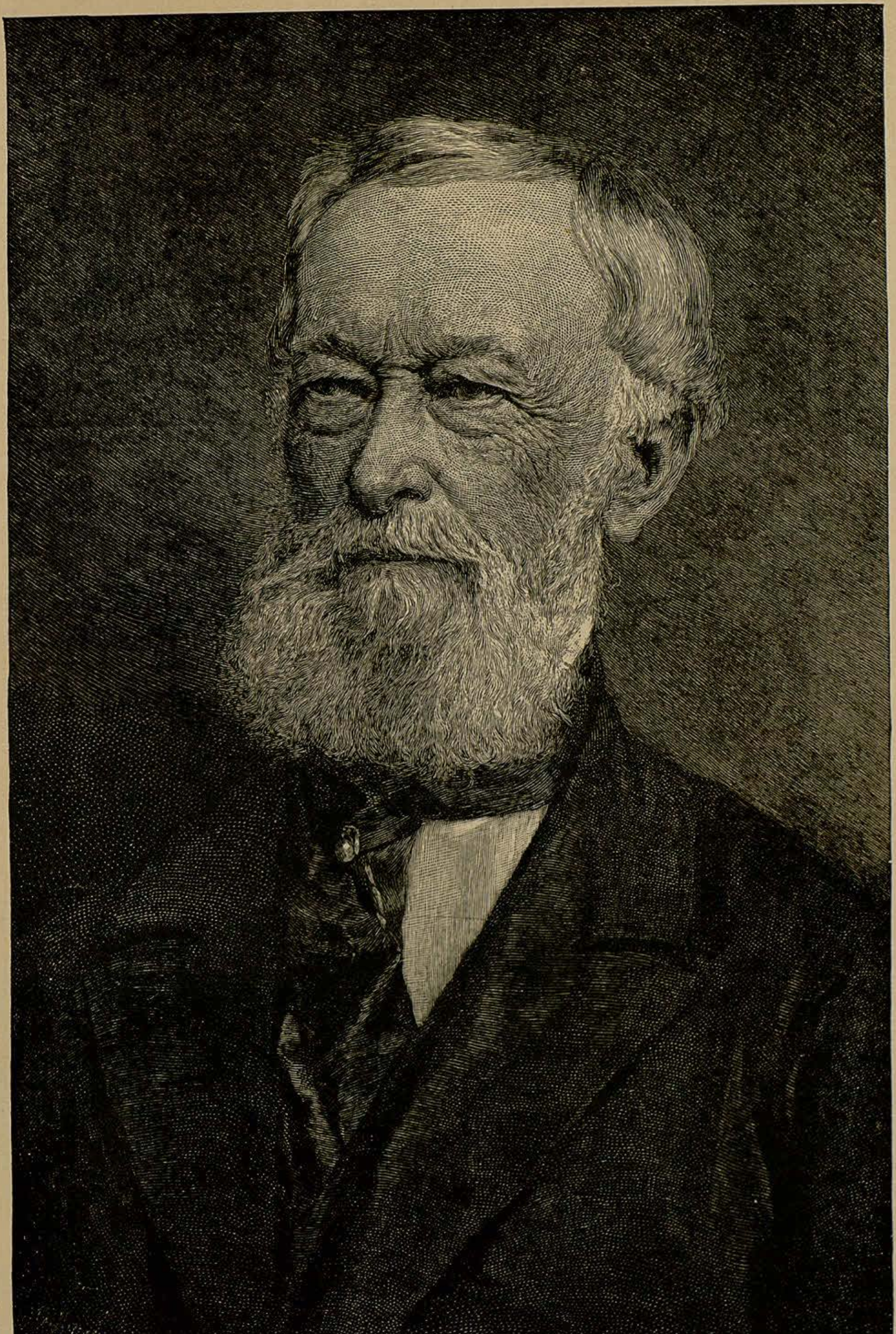
The work to be done by an unarmored cruiser must be done from a distance when risking an engagement with an armored enemy. The superiority of armament must compensate for deficiency in defensive power which precludes close quarters. To make these ships effective they must be armed with guns capable of doing an extraordinary amount of work, and yet the size of the vessels will not admit of their carrying guns of immense weight. In order to get this amount of work out of a compar-



A KRUPP GUN ON A NAVAL CARRIAGE.

atively light gun, we must secure great initial velocity for the projectile. This can only be done by burning a large charge of powder, which involves a long bore in which to burn it, while care is necessary to secure a large margin of strength in the material of which the gun is constructed. These essential demands required a radical change in the form and material of our present armament; they also forced a change in the method of construction.

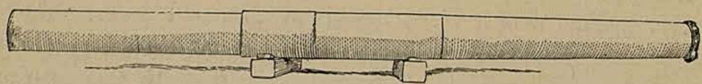
The superior fitness for cannons of steel over cast-iron was recognized many years ago, but the difficulty of casting steel in large masses pre-



ALFRED KRUPP.

vented the introduction of steel guns, and the generally acceptable treatment of cast-iron made it answer satisfactorily the demands for gun-metal not subjected to unusual strains. Mr. Frederick Krupp, of Essen, in Germany, was the first steel manufacturer who succeeded in casting steel in large masses, and he produced a number of steel guns cast from crucibles in solid ingots, which were bored, turned, and fashioned as in the case of cast-iron smooth-bore guns. These guns held a position in advance of other manufactures on the score of strength of material. But the introduction of the rifle system, the call for higher velocities, the increased charges of powder, with the consequent increase of strain, enhanced by the friction attending the passage of the projectile forced along the bore, had the effect of calling attention to the weakness that was inherent in the method of construction of cannons. It is well known that an explosive force operating in the interior of a hollow cylinder of any thickness is not felt equally throughout the wall of metal; the parts near the seat of explosion are called upon to do much more work in restraining the force generated than are the parts more remote. It has been determined that the strain brought upon the portions of the wall is in inverse proportion to the squares of their distances from the seat of effort. Thus, in a gun cast solid, if we take a point two inches from the bore, and another four inches from the bore, the strain felt at those points respectively will be inversely in the proportion of four to sixteen, or, in other words, the metal at two inches from the bore will be strained four times as much as that at the distance of four inches. From this it can be seen that the metal near the seat of effort may be strained beyond its tensile strength, while that more distant is only in partial sympathy with it. Rupture thus originates at the interior portion, and the rest of the wall yields in detail. No additional strength of material can change this relationship between the parts; they result from a law, and show that this method of construction for a cannon is untrustworthy where the strains approach the tensile strength of the material.

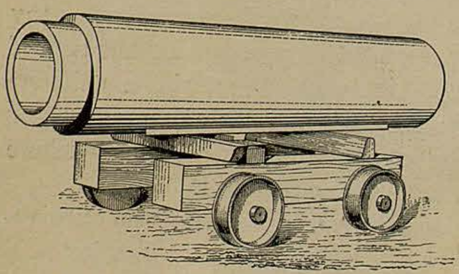
The means of providing against this successive rupture of over-strained parts is found in the "built-up gun," in which an interior tube is surrounded by encircling hoops of metal, which are shrunk on at sufficient tension to compress the portions which they enclose. This is the principle of "initial tension," which is the basis of the modern construction of cannons. By adopting this method, an ingot to form a tube to burn the required amount of powder can be cast of a light weight in comparison with what would be needed for a complete gun, and the strength and number of reinforcing rings to be shrunk around it can be readily determined, proportioned to the known strain that will be brought upon the bore of the piece. The late developments in the manufacture of steel by the open-hearth process remove all difficulty to procuring the necessary metal in masses suitable for all parts of the heaviest guns.



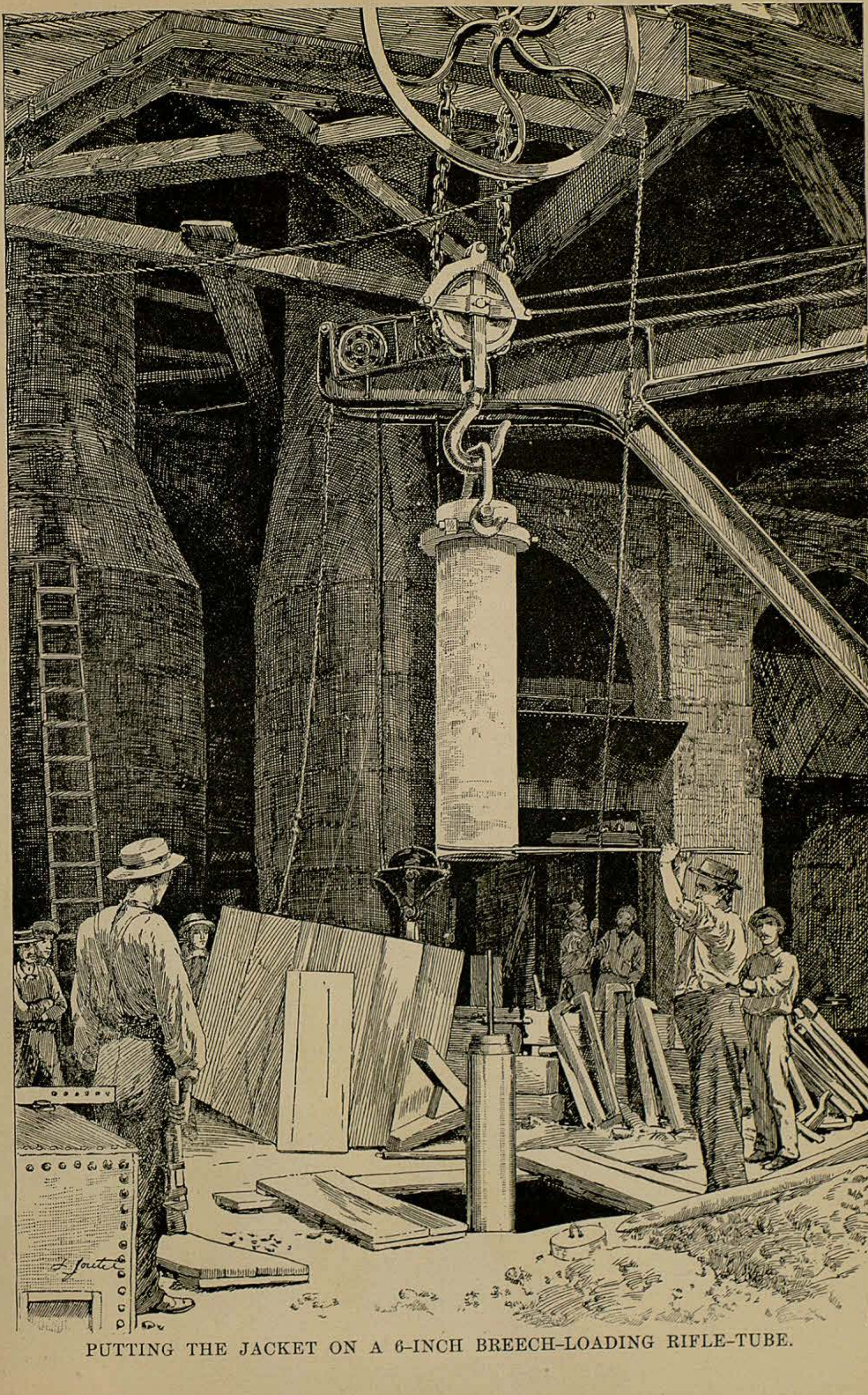
BREECH-LOADING RIFLE-TUBE READY FOR RECEIVING JACKET.

The built-up steel gun is the one now adopted in Europe by the leading powers, and it is the gun with which the United States navy will be armed; but, before its final adoption, efforts were made to convert old smooth-bore cast-iron guns into rifles, and to construct new guns partially of steel and partly of wrought-iron. As some of these methods of conversion offered an economical means of acquiring rifled cannons, our naval authorities were led into the error of countenancing the effort to a moderate degree.

The system that was adopted was that originally suggested by Mr. P. M. Parsons in England, which was afterwards patented by Major Palliser, R. A., and bears his name. It consisted in enlarging the bore of a cast-iron gun, and inserting a tube of wrought-iron formed of a bar arranged in the form of a coil when heated. The tube was expanded by firing charges of powder, and afterwards rifled. The guns are muzzle-loaders, and are not increased in length beyond that of the cast-iron gun which forms the casing for the tube. The length is thus limited in order to preserve the preponderance of the piece, and because of the want of longitudinal strength in the coil, which cannot be depended on beyond a few tons' strain; the arrangement of metal in a coil provides very well for circumferential or tangential strains, but in the Palliser conversion the longitudinal strength depends on the cast-iron casing. The idea of the coiled wrought-iron tube originated with Professor Treadwell, of Harvard University, in 1841. He utilized it by enclosing a tube of cast-iron or steel in the



BREECH-LOADING RIFLE-JACKET, ROUGH-BORED AND TURNED.



PUTTING THE JACKET ON A 6-INCH BREECH-LOADING RIFLE-TUBE.

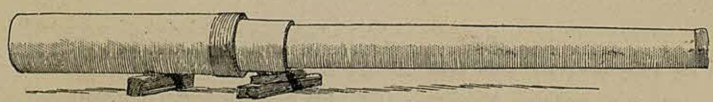
same manner as it is applied in the wrought-iron Armstrong and Woolwich guns.

The administration of our naval ordnance has abandoned conversions, and has concentrated its efforts on the production of an armament of built-up steel guns. The system of construction that has been adopted originated in England, but was for many years ignored by the government authorities. It involved the use of steel in all its parts, and this was charged as an objection, as confidence in this metal was not established in the minds of the English artillerists. That government committed itself entirely to the wrought-iron gun proposed by Mr. (now Lord) Armstrong, whose system was a reproduction of that successfully experimented on by Professor Treadwell, and the entire force of the government works at Woolwich and of the Armstrong works at Elswick-on-the-Tyne was occupied with the production of this style of ordnance. The English steel gun invented by Captain Blakely and Mr. J. Vavasseur was ignored in England, but its merit could not be suppressed, and its superiority has forced a tardy recognition by that government.

This gun came prominently into notice for a short time at the breaking out of the war of the rebellion: some guns were imported for the service of the Southern States. At the exhibition in London in 1862 a Blakely 8.5-inch gun was one of the features of attraction in the department of ordnance. The principle of the construction was shown in this gun, consisting in shrinking a long jacket of steel around an enclosed steel tube, the jacket extending to the trunnions. Mr. Vavasseur was the manager of the London Ordnance Works, and was associated with Captain Blakely in the manufacture of his earlier guns, but the entire business soon fell into the hands of Mr. Vavasseur, whose name alone is associated with the succeeding developments of the gun.

In 1862 the guns manufactured by Mr. Krupp were solid forgings. He advanced but slowly towards the construction of built-up cannons, and it was not until the failure of some of his solid-cast guns that he entered on the built-up system. His first steps were to strengthen the rear portion of new guns by shrinking on hoops, and to increase the strength of old guns he turned down the breech and shrunk on hoops. He confined this system of strengthening to the rear of the trunnions until he was reminded of the necessity of strength along the chase of the gun by the blowing off of the chase of some 11-inch guns of his manufacture. His system was then modified so as to involve reinforcing the tube of the larger calibred guns along its whole length with hoops, and his later and largest productions are provided with a long jacket reinforcing the entire breech portion of the tube—a virtual adoption of the great element of strength which has always formed the essential feature in the Vavasseur gun which is now adopted in the United States navy.

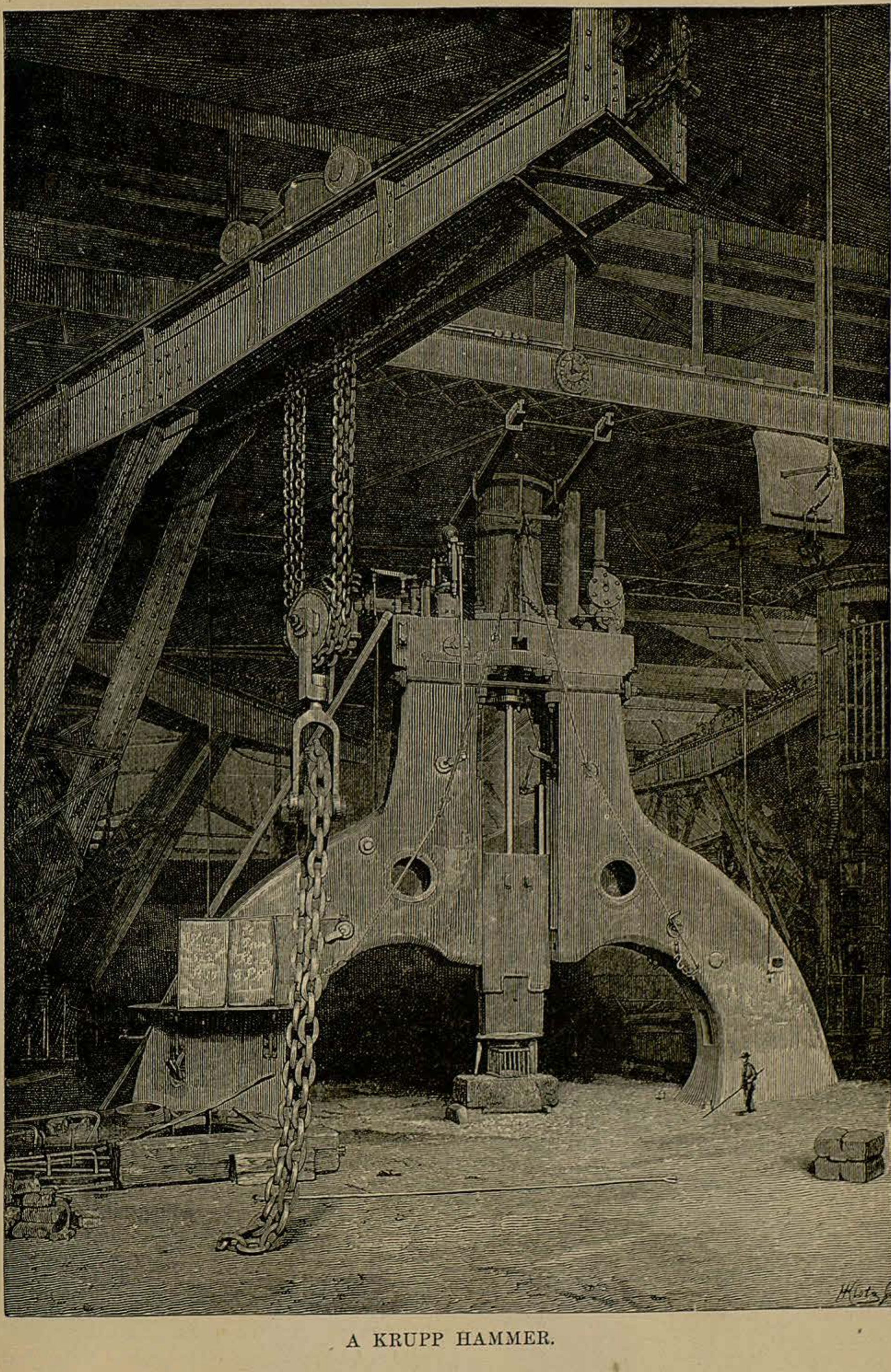
In the building up of the steel gun for the navy advantage is so taken of the elastic characteristic of the metal that all parts tend to mutual support. The gun proper consists of a steel tube and a steel jacket shrunk around it, reaching from the breech to and beyond the location of the trunnion-band. Outside the jacket and along the chase of the gun there are shrunk on such hoops as the known strain on the tube may make necessary for its support. The tube is formed from a casting which is forged, rough-bored, and turned, and then tempered in oil, by which its elasticity and tensile strength are much increased. It is then turned on the exterior, and adjusted to the jacket, the proper difference being allowed for shrinkage. The jacket, previously turned and tempered, is then heated, and rapidly lowered to its place. The front hoops



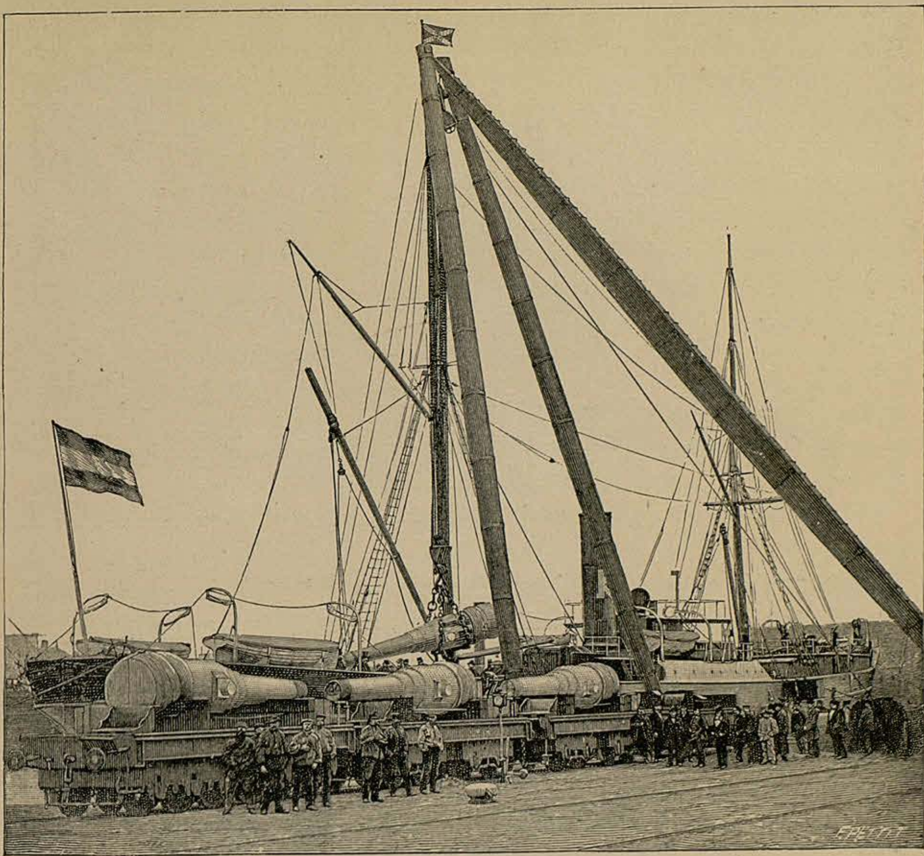
BREECH-LOADING RIFLE AFTER RECEIVING JACKET.

over the chase are then put on, and the gun is put into a lathe and turned to receive the trunnion-band and rear and front hoops. The gun is then fine-bored and rifled.

Each part, as successively placed in position, is expected to compress the parts enclosed through the initial tension due to contraction in cooling. This tension is the greater the farther the part is removed from the tube; thus the jacket is shrunk on at a less tension than are the encircling hoops. By this means full use is made of the elastic capacity of the tube which contributes the first resistance to the expanding influence of the charge. The tension of the jacket prevents the tube being forced up to its elastic limit, and it in turn experiences the effect of the tension of the other encircling parts which contribute to the general support; thus no part is strained beyond its elastic limit, and on the cessation of the pressure all resume their normal form and dimensions. A comparison of this method of common and mutual support of parts with that given by the wall of a gun cast solid will serve to demonstrate the superior strength of the construction. In order to achieve this intimate



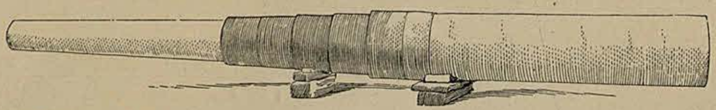
A KRUPP HAMMER.



TRANSPORTING CANNON AT BREMERHAVEN.

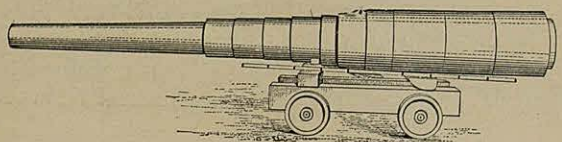
working of all the parts it is necessary that the metal of which they are respectively composed must be possessed of the same essential characteristics; in a word, the gun must be homogeneous. It was the absence of this feature in the Armstrong gun which has caused its abolition. This gun was built up, and the parts were expected to contribute mutual support, but the want of homogeneity between the steel tube and the encircling hoops of wrought-iron made it impossible for them to work in accord, in consequence of the different elastic properties of the two metals, which, after frequent discharges, resulted in a separation of surfaces between the tube and hoops, when the tube cracked from want of support.

In the construction of the guns for the United States navy, as in the new steel guns now being manufactured in England, the theory of the built-up system is practically conformed to; more so than by Krupp or the French artillerists, who use a thicker tube than is considered judicious at Woolwich or at the Washington navy-yard. Any increase of thickness of the tube beyond what is necessary to receive the initial pressure of the charge is open to the objections made to the gun with a solid wall, the proportion of the strain communicated to the hoops is reduced, and rupture may ensue from overstraining the tube. The thicker the tube, the less appreciable must be the compression induced by the tension of the encircling hoops.

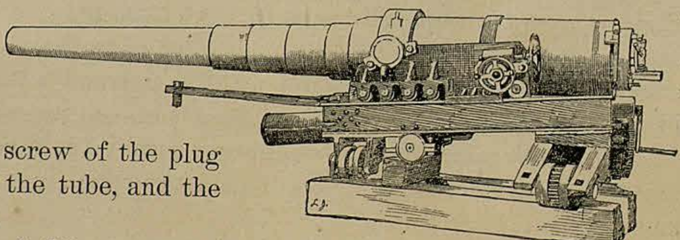


BREECH-LOADING RIFLE AFTER RECEIVING JACKET AND CHASE HOOPS.

The gun is a breech-loader. The system adopted for closing the breech is an American invention (see note, p. 257), but having been employed in France from the earliest experimental period, it is known as the French *fermeture*. A screw is cut in the rear end of the jacket to the rear of the tube, and a corresponding screw is cut upon a breech-plug. The screw threads are stripped at three equidistant places, the screw and plane surfaces alternating, thus forming what is called an "interrupted" or "slotted" screw. The screw portions of the breech-plug enter freely along the plane longitudinal surfaces cut in the tube, and being then turned one-sixth of its circumference, the screw of the plug locks in that of the tube, and the breech is closed.



BREECH-LOADING RIFLE WITH JACKET, CHASE HOOPS, AND JACKET HOOPS IN PLACE.



U. S. N. 6-INCH BREECH-LOADING RIFLE.

The success of this system of

breech mechanism was not so pronounced on its introduction as it is to-day. The plug forms the base of the breech of the gun, and all the effort of the gases to blow out the breech is exerted at this point. The impact upon the end of the plug is very severe, and has a tendency to *upset* the metal, thereby increasing the diameter of the plug, which would prevent its removal after the discharge of the piece. With quick-burning powder, as was generally in use for cannons at the inception of the breech-loading experiments, this result ensued if the charges of powder were carried above a certain limit, and the consequent restriction that was put upon velocities was a serious obstacle to the adoption of the system; but the progress that has been made of late years in the science of gunpowder manufacture has relieved the subject from this embarrassment, powder being now provided which communicates very high velocities while developing pressures so moderate and regular as to be entirely under the control of the artillerist.

The original guns, four in number, constructed with breech mechanism on the French *fermeture* principle for the British government during the Crimean war are now in the "Graveyard" at Woolwich Arsenal.

The projectiles for the new armament are of two kinds; both, however, are shells. That for ordinary use against unarmored vessels is styled the common shell, and is of cast-iron. The length bears a uniform proportion to the gun, being in all cases three and a half calibres. The armor-piercing shell is made of forged steel, and is three calibres in length. The following table gives the particulars, approximately, of the common shell:

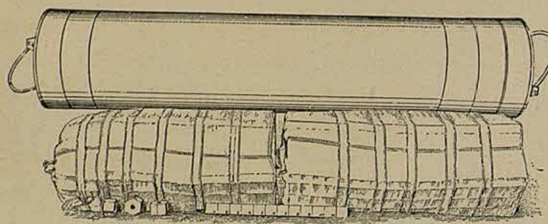
Gun.	Length.		Weight.	Bursting Charge.
	Inches.	Calibre.	Pounds.	Pounds.
5-inch breech-loading rifle....	17.97	3.59	60	2
6-inch breech-loading rifle....	20.90	3.48	100	4
8-inch breech-loading rifle....	28.10	3.51	250	12
10-inch breech-loading rifle....	35.00	3.50	500	22
12-inch breech-loading rifle....	42.00	3.50	850	38
16-inch breech-loading rifle....	56.00	3.50	2000	90

The armor-piercing shell of the same weight is reduced in length, and its walls are thicker; the bursting charge is consequently much reduced. The following are the particulars, approximately determined:

Gun.	Length.		Weight.	Bursting Charge.
	Inches.	Calibre.	Pounds.	Pounds.
5-inch breech-loading rifle....	15.07	3.01	60	1
6-inch breech-loading rifle....	17.91	2.98	100	1.50
8-inch breech-loading rifle....	24.25	3.03	250	3.50
10-inch breech-loading rifle....	30.00	3.00	500	7
12-inch breech-loading rifle....	36.00	3.00	850	14
16-inch breech-loading rifle....	48.00	3.00	2000	30

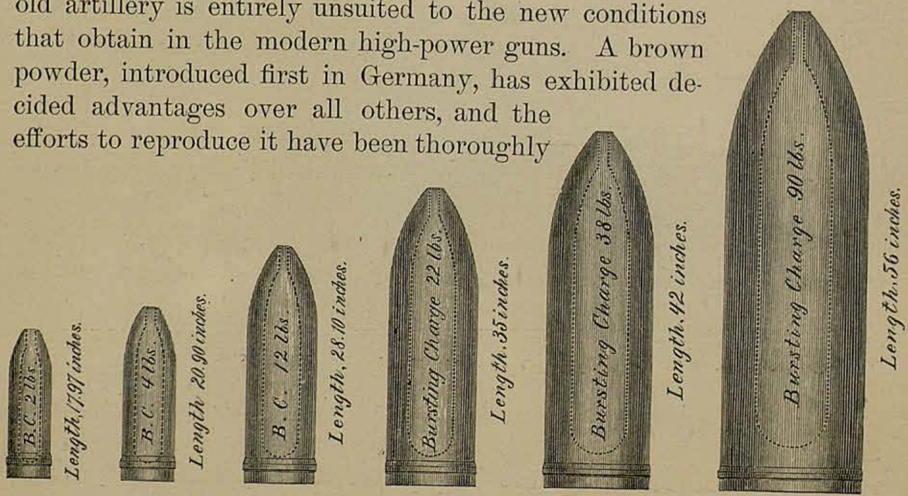
The rifle motion is communicated by one rotating ring of copper, which is placed at the distance of 1.5 inch from the base of the projectile.

The uniform windage for all calibres is .04 inch; thus, taking the 6-inch gun as an example, the diameter of the bore across the lands is 6 inches, the diameter of the shell is 5.96 inches, the depth of the grooves is .05 inch; thus the diameter of the bore across the grooves is 6.10 inches. In order to permit the rotating ring to fill the grooves, it must have a diameter of 6.14 inches; this causes a *squeeze* of .05 inch between the lands and the rotating ring.



CARTRIDGE CASE AND GRAINS OF POWDER, U. S. N.

There is no subject in the development of the new naval artillery more important than the powder. That used with the old artillery is entirely unsuited to the new conditions that obtain in the modern high-power guns. A brown powder, introduced first in Germany, has exhibited decided advantages over all others, and the efforts to reproduce it have been thoroughly



COMMON SHELLS, U. S. N.

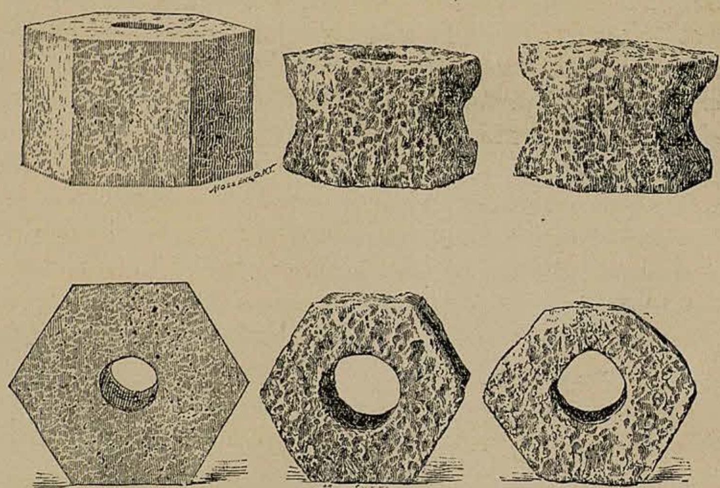
successful at the Du Pont Mills. It is generally known as "cocoa" powder. Its peculiarity exists in the method of preparing the charcoal; this affects the color, and results in a brown instead of a black powder. With this powder, experiments with the 6-inch gun give a muzzle velocity of over 2000 feet per second with a projectile of 100 pounds, using charges of 50 pounds, and this result is obtained with less than 15 tons pressure per square inch in the powder chamber. The grain is prismatic, with a central perforation, and as regards its rate of burning, is under complete control in the manufacture; the form provides an increasing surface for the flame during the period of combustion, thus relieving the gun from abnormal pressures at the moment of ignition, but continuing the extreme pressure farther along the bore. The progressive nature of the combustion is very apparent when comparing an unburned grain with others partially consumed, blown out from the gun.

The gun-carriage, which is a separate study in itself, is carried to a high pitch of perfection, and presents many features being adopted abroad. The importance of a suitable carriage can be appreciated by inspecting the following table, which exhibits the *energy* that must be controlled by it:

Gun.	Weight of Charge.	Weight of Projectile.	Muzzle Velocity.	Muzzle Energy.	Penetration in Wrought-iron.	Muzzle Energy per Ton of Gun.	Weight of Gun.	Weight of Carriage.
	Pounds.	Pounds.	Feet.	Ft.-Tons.	Inches.	Ft.-Tons.	Pounds.	Pounds.
5-inch steel breech-loading rifle..	30	60	1915	1,525	10.7	552	6,187	4,200
6-inch steel breech-loading rifle..	50	100	1915	2,542	13.2	521	11,000	6,400
8-inch steel breech-loading rifle..	125	250	2050	7,285	18.2	560	28,000	14,000
10-inch steel breech-loading rifle..	250	500	2100	15,285	23.7	588	58,240	32,482
12-inch steel breech-loading rifle..	425	850	2100	25,985	27.6	591	44 tons	....
14-inch steel breech-loading rifle	675	1350	2100	41,270	32.2	550	75 tons	....
16-inch steel breech-loading rifle..	1000	2000	2100	61,114	36.8	571	107 tons	....

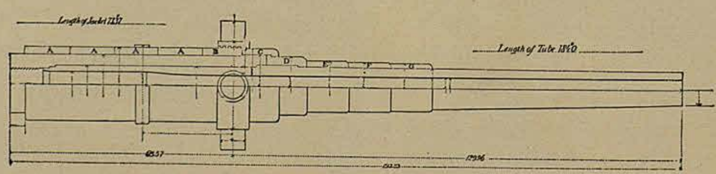
This *energy*, total energy, expresses the work that the gun can perform. It is expressed in foot-tons, and signifies that the energy developed is sufficient to raise the weight in tons to a height of one foot. Thus the projectile from the small 5-inch gun, weighing sixty pounds, fired with a charge of thirty pounds of powder, leaves the gun with an energy capable of lifting 1525 tons to the height of one foot! Comparing this with the energy developed by the 100-ton hammer at the forge of Le Creuzot in France, the energy of which is 1640 foot-tons, we have a most striking illustration of the power of gunpowder, and the testimony in the table as to the energy developed per ton of gun more forcibly exhibits the perfection of a manufacture which, with so little weight of gun, can develop such gigantic power.

It is this power, united with a moderate weight of gun, which will enable our unarmored cruisers to hold their own with vessels moderately armored. The power of the battery is greater than is required to contend with unarmored ships, there is a great surplus of power of offence,



UNBURNED AND PARTIALLY CONSUMED GRAINS OF U. S. N. POWDER.

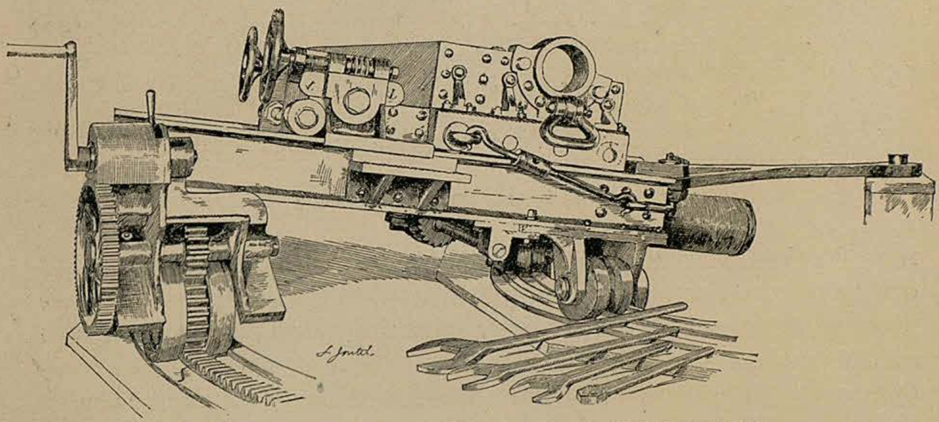
and the effort is very properly made to sustain this at the highest practicable point. The table shows that the 5-inch gun can perforate 10.7 inches of wrought-iron at the muzzle; but the results given in tables are based on deliberate firing made on a practice-ground, with the position of the target normal to the line of fire. Such conditions cannot obtain during an action at sea, for, besides the modified effect caused by increased distance of target, it must be borne in mind that the side of an enemy's ship will be presented at varying angles, which introduces the element of deflection, than which no cause is more detrimental to penetration. Though the table states a fact, the practical effect of the projectile will be far less than is stated, hence the wisdom of providing a large surplus of power to compensate for the resistance to its operation.



SECTION OF U. S. N. 6-INCH BUILT-UP STEEL BREECH-LOADING RIFLE.

It will readily be conceded that the artillerist has a very responsible duty to perform in so designing his gun that the parts shall lock and interlock to guard against chance of dislocation in the structure. A study of the illustration of the 6-inch built-up gun as constructed at the Washington navy-yard will show the system there adopted.

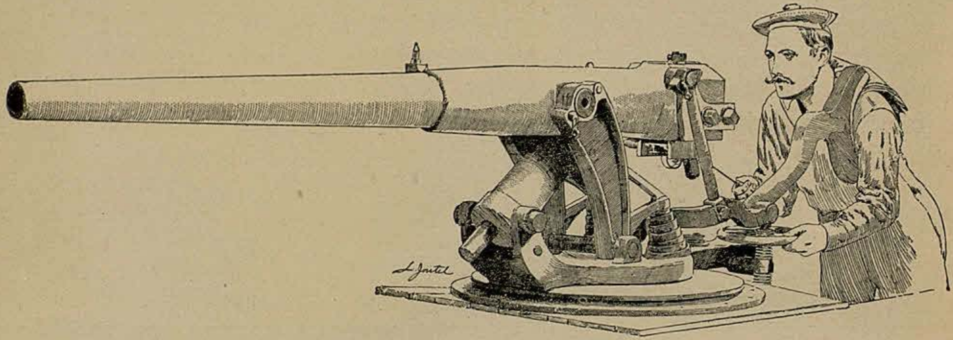
In the list of guns each calibre is represented by one gun. We have not, as of old, several guns of the same calibre differing in weight; multiplicity of classes will be avoided; but this will apply only to the main battery, for history is singularly repeating itself at this time in the restoration of the "murdering pieces" which have been cited as forming part of naval armaments in the seventeenth century. The needfulness of machine guns for operating against men on open decks, for effecting entrance through port-holes, for repelling attacks in boats, and



BROADSIDE CARRIAGE FOR 6-INCH BREECH-LOADING RIFLE.

for resisting the approach of torpedo-boats, is so widely recognized that no vessel of war is considered properly equipped without a secondary battery of these "murdering pieces." They are mounted on the rail, on platforms projecting from the sides and in the tops. The types adopted in the United States navy are the Hotchkiss revolving cannon and rapid-firing single-shot guns, and the smaller calibre machine guns of Gatling. The heavier pieces, throwing shells of six pounds weight, are very effective against vessels of ordinary scantling.

In contemplating the present condition of our new naval armament we have the consolation of knowing that, so far as concerns the study of the subject generally and in detail, the designs, and the initial manufacture, all has been done that could have been done with the resources available. What has been achieved has been without the facilities that are provided in modern gun factories; but notwithstanding all the drawbacks, it is probably safe to assert that no guns in the world to-day are superior to those that have been fabricated at the Washington navy-yard of steel on the new adopted pattern. The work at this ordnance yard is carried on without ostentation; there is no flourish of trumpets accompanying its operations; it is not advertised, and the people do not yet know how much they owe to the ordnance officers of the



RAPID-FIRING SINGLE-SHOT HOTCHKISS GUN.

navy for the initiation of this new industry, which enables us to assert our ability to advance in this manufacture through the incontrovertible proof of work accomplished. The results are meagre in quantity, and at the present rate of manufacture it will require many years to equip our fleet with modern artillery; this should be remedied, as there is now no doubt as to the success of the productions of this establishment. The plant should be enlarged on a liberal and well-matured plan, and the work should be encouraged by generous appropriations.

It may not be generally known that the steel forgings required for the few 8-inch and the two 10-inch guns now in hand were imported from abroad, for the reason that they could not be furnished of domestic manufacture, from the want of casting and forging facilities in the United States for work of such magnitude. This was a deficiency in our resources that required prompt attention to secure us a position of independence in this important matter. The method of achieving the object was carefully studied out by a mixed board of army and navy officers, and presented in a document known as the "Gun Foundery Board Report," and the subject received the attention of committees from both Houses of Congress. All of these reports virtually agreed as to the method, but there was a useless delay in action; large expenditures of money were required, and there was hesitancy in assuming the responsibility of recommending it. The object was of national importance, however, and public opinion demanded its accomplishment. The officers of the navy have proved their ability to carry on the work successfully; and if the opportunity be given they will establish the artillery of the United States navy in a position of which the country may again be proud.

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NOTES.

GUNS.

THE United States no longer depend upon foreigners for guns or armor, inasmuch as the circular issued in August, 1886, by the Navy Department inviting all domestic steel manufacturers to state the terms upon which they were willing to produce the steel plates and forgings required for ships and ordnance, has met with a prompt response. About 4500 tons were needed for armor, in plates varying from 20 feet by 8 feet by 12 inches thick, to 11.6 feet by 4.3 feet by 6 inches thick; and of the 1310 tons of steel forgings, 328 tons were intended for the 6-inch guns, 70 tons for the 8-inch, and 912 tons for the calibres between 10 and 12 inches, both inclusive. The rough-bored and turned forgings required by the contract were to weigh 3¼ tons for the 6-inch calibres, 5 tons for the 8-inch, 9½ tons for the 10-inch, 9¾ tons for the 10½-inch, and 12½ tons for the 12-inch. From the time of closing the contract twenty-eight 6-inch forgings were to be delivered in one year, and the remainder within eighteen months. All the 8-inch were to be ready within two years, and the 10-inch and larger calibres within two years and a half. The proposals opened on the 22d of last March showed that for the gun-forgings the Cambria Iron Company had bid $851,513, the Midvale Steel Company $1,397,240, and the Bethlehem Iron Company $902,230; and that for the armor-plates the Bethlehem Company had bid $3,610,707, and the Cleveland Rolling-mill Company $4,021,561. Subsequently the Navy Department awarded the contract to the Bethlehem Company, which agreed to furnish all the required steel at a total cost of $4,512,938.29.

The tests are so rigorous that a high quality of steel is sure to be produced. The specifications require the forgings to be of open-hearth steel of domestic manufacture, from the best quality of raw material, uniform in quality throughout the mass of each forging and throughout the whole order for forgings of the same calibre, and free from slag, seams, cracks, cavities, flaws, blow-holes, unsoundness, foreign substances, and all other defects affecting their resistance and value. While it is prescribed that the ingots shall be cast solid, latitude is given to the method of production; but no matter what method may be employed, the part to be delivered for test and acceptance must be equal in quality and in all other respects to a gun ingot cast solid in the usual way, from which at least 30 per cent. of the weight of the ingot has been discarded from the upper end and 5 per cent. from the lower end.

For breech-pieces each ingot must be reduced in diameter by forging at least 40 per cent.; in case tubes are forged upon a mandrel from bored ingots, the walls must be reduced in thickness by forging at least 50 per cent. Forgings are to be annealed, oil tempered under such conditions as will assure their resistance and again annealed, and no piece will be accepted unless the last process has been an annealing one. The forging must be left with a uniformly fine grain.

All these excellent results are the direct outcomes of the report made in 1884 by the Ordnance Board. 1st. That the army and navy should each have its own gun-factory; 2d. That the parts should be shipped by the steel-makers ready for finishing and assembling in guns; 3d. That the government should not undertake the production of steel of its own accord; 4th. That the Watervliet Arsenal, West Troy, N. Y., should be the site of the army gun-factory; and 5th. That the Washington navy-yard should be the site of the navy gun-factory. No action was taken upon the recommendation to establish gun-factories; but at the first session of the Forty-ninth Congress an appropriation of $1,000,000 was made for the armament of the navy, of which sum so much as the Secretary determined might be employed for the creation of a plant. Under this permission the gun-factory at the Washington navy-yard is now being established.

The construction of the breech-loading steel guns for the new cruisers has been energetically pushed. Slight modifications in the original designs were made necessary by the adoption of slower burning powder, which carried the pressure still farther forward in the bore, and, in the case of some foreign guns, caused their destruction. Though our guns have not suffered from any such accident, it has been deemed a wise precaution to give the 8-inch guns of the *Atlanta* two additional chase-hoops, and to hoop all other pieces of this calibre to the muzzle.

From a memorandum kindly furnished by Lieutenant Bradbury, United States navy, it is learned that the number and calibre of the new guns now finished, under construction, or projected, are as follows:

Name of Ship.	Calibre.				
	5-inch.	6-inch.	8-inch.	10-inch.	12-inch.
Dolphin	None.	1	None.	None.	None.
Atlanta*	"	6	2	"	"
Boston*	"	6	2	"	"
Chicago†	2	8	4	"	"
Gun-boat No. 1†	None.	6	None.	"	"
Gun-boat No. 2	"	4	"	"	"
Newark	"	12	"	"	"
Baltimore	"	6	2	"	"
Charleston	"	6	None.	2	"
Miantonomoh	"	None.	"	4	"
Terror	"	"	"	4	"
Amphitrite	"	"	"	4	"
Monadnock	"	"	"	4	"
Puritan	"	"	"	4	"
Armored cruiser	"	6	"	4	"
Armored battle-ship‡	"	6	"	None.	2
2 Gun-boats	"	12	"	"	None.
2 Cruisers	"	24§	"	"	"
Floating batteries	"	None.	"	"	8§

This gives a total of two 5-inch, one hundred and three 6-inch, ten 8-inch, twenty-six 10-inch, and ten 12-inch. In his last report, Captain Sicard, Chief of Ordnance, states that "for the new ships approaching completion we have eighteen 6-inch, three 8-inch, and two 5-inch guns finished, and three 6-inch and five 8-inch well advanced, together with all the carriages for the *Atlanta* and *Boston*, and all for the *Chicago*, except the 8-inch. . . . With brown powder the following are the best results obtained in the 6-inch and 8-inch guns.

Gun.	Powder.	Muzzle Velocity.	Pressure.
		Foot seconds.	Tons.
6-inch	American Brown.	2,105	15.6
8 inch	Westphalian Brown.	2,013	15.5

"It will be observed," he adds, "that the muzzle velocities are as high, while the chamber pressures are considerably below those which the guns were calculated to support in service."

During the preliminary trials afloat of the *Atlanta's* battery in July, a few minor faults were unfairly given an importance by the newspapers which led the country to believe that the ship and her armament were useless. Unfriendly critics vented their spite and aired their ignorance in condemnations which included all who had had anything to do,

* Complete. † Building at South Boston and West Point.

‡ It is probable that the battery of the battle-ship will be two 6-inch, two 10-inch, and two 12-inch guns. § Probably.

even in the remotest degree, with the design and construction of vessel and gun. Indeed, so bitter and persistent were they that for a time it seemed almost hopeless to expect any further good could come out of the Nazareth of public opinion. It was not a question of politics, for the journalists of every political faith ran amuck riotously upon the subject; nor was it a matter of morals, where, through intelligent discussion, better things could be attained, for with brilliant misinformation and dogmatic dulness each scribe stuck his pin-feathered goose-quill into the navy's midriff—it being such an easy, such a safe thing to do—and then thanked Heaven he was a virtuous citizen. Finally, a board was appointed to inspect the ship and battery, and after a thorough examination it made the following report:

"In obedience to the Department's order of the 22d instant, the Board convened on board the *Atlanta*, Newport, Rhode Island, on the 25th instant (July, 1887), and made a careful examination of the ship, guns, carriages, and fittings, and of the damage sustained during the recent target practice, as reported by the board of officers ordered by the commanding officer of the *Atlanta*. The Board proceeded to sea on the morning of the 25th instant, but were prevented from firing the guns by a heavy fog which prevailed throughout the day. The ship was again taken to sea on the morning of the 27th instant, and the guns were fired. No deficiencies were noted in the guns themselves other than a slight sticking of the breech-plug in 6-inch breech-loading rifle No. 5 (this disappeared during the firing), some difficulty in the management of the lock of 6-inch breech-loading rifle No. 4, caused by slight upsetting of the firing-pin, and the bending of the extractor in 6-pounder rapid-fire No. 5.

"The recoil and counter-recoil of the 8 and 6 inch guns were easy and satisfactory, except at the second fire of the 8-inch breech-loading rifle No. 1, when the gun remained in. (This was readily run out with a tackle.) The action of the carriage of 8-inch breech-loading rifle No. 1 at the first fire was due to want of strength in the clips and clip circles, and at the second fire to want of sufficient bearing and securing of the deck socket. It is believed that had the deck socket held, the carriage would not have been disabled by the giving way of the clips. The training gear, steam and hand, was uninjured; the gun was readily trained when run out to place. The action of the after 6-inch shifting gun No. 4 was satisfactory, notwithstanding that the front clips had a play of half an inch. The action of the broadside carriages of 6-inch guns Nos. 5 and 18 was satisfactory, except the breaking of clips, the starting of the copper rivets in the clip circles, and the wood screws in the training circles.

"It is believed from the action of the carriage of 6-inch breech-loading rifle No. 5, when the clips were removed, that the carriages can be safely used without clips. The clips, however, give additional security and steadiness to the carriage, and assist the pivot and socket in bearing the shock of the discharge. The firing of the 6-pounder rapid-fire guns developed a weakness in one leg of the cage mount of No. 4, due to imperfect workmanship, and showed also the necessity of locking nuts on the bolts that secure the mounts to the ports. The tower mounts of the 3-pounder rapid-fire guns are unsatisfactory. They cannot be moved with facility; the line of sight of the gun is obstructed at ranges beyond 1600 yards, and the guns cannot be safely used as now fitted. For this reason 3-pounder rapid-fire No. 3 was not fired. The tripod mounts of the 1-pounder rapid-fire guns need stronger holding-down arrangements. The tower mounts of the 47-millimetre revolving cannon are like those of the 3-pounder rapid-fire guns, and have the same defects. The mounts of the 37-millimetre in the tops are satisfactory.

"Careful observation of the effect of the firing upon the hull of the vessel failed to develop any damage other than the breaking of the cast-steel port-sills and the starting of some light wood-work. The shock of discharge was slight on the berth-deck, and observers there were unable to observe which 6-inch gun had been fired. The deck, hull, and fittings, with the exception of the port-sills, hinges to superstructure doors and vegetable lockers, and some of the light wood-work, have every appearance of strength and ability to endure the strain of continuous firing of the guns. The blast of the forward 8-inch gun, when fired abaft the starboard beam, will not permit the crews of the starboard 3-pounder rapid fire and 1-pounder rapid fire to remain at their guns. When the after 8-inch gun is fired forward of the port beam, the crews of the after 47-millimetre revolving cannon and of the port after 1-pounder rapid fire cannot remain at their guns. When the forward 6-inch shifting gun is fired on the port bow or directly ahead, the crew of forward 8-inch gun cannot remain at their places. When the after 6-inch shifting gun is fired on the starboard quarter or directly aft, the crew of the after 8-inch gun cannot remain at their gun. The inability to fire parts of the secondary battery under certain conditions is due to the great arc of fire given to the 8-inch guns. This can hardly be called a defect. It is thought that a screen can be placed between the 8 and 6 inch guns which will enable them to be worked together forward or aft.

"The pivot socket of the 8-inch carriage should have a broader bearing surface, and should be rigidly bolted to the steel deck and to the framework of the ship in such manner as to distribute the strain over a larger area. The clips and clip circles of the 8-inch and 6-inch carriage should be made of steel. The clips should have larger bearing surfaces, and should be shaped to fit the circle. The circle should have double flanges, and be bolted (not riveted) on each flange to the steel deck. There should be no appreciable play between the clips and the circles. All bolts used in the battery fittings should have the nuts locked.

"The clip rail of the tower mount should be altered to fit the mount. This change will make the compressors effective, and allow the guns to be used with safety. The port-sills should be replaced by heavier sills, made of the best quality of malleable cast-steel. The plan of testing the hull, guns, and fittings of the *Atlanta* arranged by the Board contemplated a more extended use of the main battery, but the weakness developed in the port-sills and in the sockets of the 8-inch carriages rendered further firing inadvisable."

Whatever conclusion may be drawn from this report, there is one fact which may serve as an important corollary. In the latest drills of the ships on the North Atlantic station, the *Atlanta* won the champion pennant for the best gunnery practice, and this with guns and carriages which were said to be completely disabled.

The safe employment of high explosives for war purposes is looked upon by many as a solution of certain vexed problems, and much time and money have been given to the subject. From the nitro-glycerine products there has been a loudly heralded advance to melinite and roborite, of which the great things expected have not yet been realized. Among the most promising attempts to use dynamite in a projectile is that made with the pneumatic gun, perfected by Lieutenant Zalinski, of the U. S. Artillery, who has courteously furnished the following description of the system:

"The pneumatic dynamite torpedo gun is a weapon which has been evolved for the purpose of projecting with safety and accuracy very large charges of the high explosives. While a gun in name and form, it is practically a torpedo-projecting machine, the propelling force used being compressed air. The use of the compressed air gives uniformity and complete control of pressures and total absence of heat. This insures entire absence of violent initial shocks from the propelling force; it also eliminates danger of increasing the normal sensitiveness of the high explosives by heating while resting in the bore of the gun. The ability to reproduce, time after time, absolutely the same pressure necessarily carries with it great accuracy of fire. The torpedo shell thrown by the gun is essentially arrow-like, and is very light and compact compared to the weight of charge thrown. This is a matter of no little importance on shipboard, as a very much larger number can therefore be carried for a given weight and storage room. The torpedoes projected by this machine have a twofold field of action when acting against ships: first, the over-water hull, second, the under-water hull.

"The shell is exploded by an electrical fuse. This is brought into action if striking the over-water hull an instant *before* full impact. If the shell misses the over-water hull and enters the water, explosion is produced *after* the shell is thoroughly buried, thus obtaining the fullest tamping effect of the water. The delayed action of the fuse can be controlled so as to cause the shell to go to the bottom before explosion ensues. This is needed at times when the torpedo shell is used for countermining a system of submerged stationary torpedo defences.

"Experiments against iron plates have shown that it is essential to have the initial point of explosion at the rear of the shell. When explosion takes place by simple impact from the front end, the injury to the plates is actually less than when a blank shell is used.

"For these reasons the fuse has been arranged so that the initial point of explosion is at the *rear* of the shell. No attempt has been made to make a shell which can perforate armor before explosion. To do so would involve thickening the walls to such an extent as to materially reduce the weight of the charge carried. Besides that, it is very doubtful whether a shell fully charged with gunpowder can perforate any considerable thickness of armor without previously exploding its bursting charge. Much more will this be the case where the bursting charge is one of the more sensitive high explosives.

"The pneumatic torpedo-gun system has various fields of usefulness as an auxiliary war appliance. Among these are the following:

"1st. On swift-moving torpedo-boats; 2d. On larger war-vessels, for general use and for defence against surface and submarine torpedo-boats; 3d. In land defences; 4th. For use in the approaches during land sieges.

"Torpedo-boats carrying the pneumatic guns can commence effective operations at the range of at least one mile, as compared to not more than three hundred yards of the boats carrying the Whitehead torpedoes. Their torpedo shell cannot be stopped by netting, as is the case with the latter. The charges which can be thrown are also much greater. The guns to be carried on the pneumatic dynamite gun cruiser now building for the United States government will throw shell charged with 200 and 400 pounds of explosive gelatine. These guns can be fired at the rate of one in two minutes, and indeed even more rapidly if required.

"In the defence of a man-of-war no other means can as effectually stop the advance either of submarine boats or submerged movable torpedoes. This is due to the ability to explode the large charges when the shells are well submerged. Their radius of action will be so great as to avoid the necessity of making absolute hits. The chances of stopping the attack are thereby very much increased.

"A tube of large calibre can be fixed in the bow, so as to be of use when advancing to the attack with the ram. An 18-inch shell, containing 1000 pounds of explosive gelatine, can be thrown 500 yards in advance of the ship, and that, too, without danger of running into the explosion of its own petard, as would be the case in ejecting directly ahead ordinary torpedoes. This will be made more clear by the statement of the relative speed of the two classes. The pneumatic gun torpedo has a mean velocity of 400 knots for a range of one mile, as compared to 25 knots for a range of 200 yards of the Whitehead torpedo. Furthermore, there is no danger of the shell turning back, as is sometimes the case with the latter.

"The opportunities of making an effective hit will be much greater with the torpedo shell than with the ram; it will be easier to point the vessel fairly at the enemy's broadside when at the range of five hundred yards than to bring the ram in absolute contact with the enemy's side. The gun-tubes used are very thin (not exceeding three-quarters of an inch in thickness), and may be of sections of any convenient length. The other portions of the supporting truss, reservoirs, etc., are also of comparatively light weight. They could be of large calibres, and the destructive effects producible by large charges of high explosives will doubtless have a demoralizing effect upon the defence."

Upon September 20th of this year a public trial was successfully made with the gun, the target being the condemned coast survey schooner *Silliman*. After firing two shots to verify the range, the gun was loaded with a projectile which was five and a half feet in length, contained fifty-five pounds of explosive gelatine, and was fired under an air pressure of 607 pounds. The torpedo rushed from the muzzle of the tube with a loud report; in thirteen seconds it plunged into the water close under the starboard quarter of the *Silliman*, and exploding almost instantly, threw a great volume of water one hundred and fifty feet into the air.

For a moment the schooner was hidden from view, but when the mist cleared away it was found that her main-mast had toppled over the side. At a distance this seemed to be all the damage inflicted, but a closer inspection showed that all the wood-ends on deck had been loosened, that the cabin fittings had been thoroughly shaken up, and that water was running into the hold.

Soon afterwards a fourth shot was fired. This landed very close to the starboard side of the vessel, and on explosion seemed to lift the *Silliman* out of the water.

The hull was very badly shattered; the water-tank, which had been firmly fastened to the schooner's bottom, was blown up through the deck and floated on the wreckage, and the stump of the main-mast was capsized. The bow was held above water by barrel buoys, and the fore-mast, which had heeled over to an angle of forty-five degrees, was sustained by the steel rigging that had become entangled in the pieces of wood floating to windward.

MACHINE AND RAPID-FIRE GUNS.

Of the machine guns, the Gatling, Gardner, Nordenfeldt, and Maxim systems are the best known. The adoption of the Accles feed in the Gatling eliminates largely the liability of cartridge jams, and increases the rapidity of fire at all angles to twelve hundred shots per minute; when this rapid delivery of fire is not needed, Bruce's slower feed may be substituted. The Gardner gun is an effective weapon, but it has less rapidity of fire and smaller range of vertical train than the Gatling. The Nordenfeldt rifle-calibre gun has not obtained the prominence of the others, and the Maxim, in which the energy of recoil is ingeniously applied to the work of loading and firing, is growing in favor. The Hotchkiss revolving cannon was a wonderful step—the 37, 47, and 53 millimetre calibres firing 1 pound, 2½ pound, and 3½ pound explosive projectiles, with muzzle velocities of about 1400 feet per second. "The heavier nature of revolving cannon," declares Commander Folger, United States Navy, "proved somewhat unwieldy, and the change to the single barrel of increased length, and using a heavier powder charge, was a natural one, and in keeping with the growing ballistic power of large guns. Though no longer denominated machine guns, the term now being generally applied to a cluster of barrels, the rapid-fire guns are a direct outgrowth of the larger calibres of machine guns, and are classed with them as secondary battery arms. There are now in the service of all the great military powers rapid-firing guns of 47 and 57 millimetre calibre, firing respectively explosive shells of 3 pounds and 6 pounds weight, at muzzle velocity of about 1900 feet per second. This will give with the 6-pound gun a range of about 2½ miles at 10 degrees elevation. These guns will deliver, under favorable circumstances, perhaps ten aimed rounds per minute, and the shells perforating the sides of an unarmored vessel, and bursting, after passing through into, say, twenty-five fragments, each with energy sufficient to kill a man, we have here a weapon of unequalled destructive capacity. It is beyond question that the conditions of combat between ships and forts are definitely changed by the advent of these guns. Even armored vessels with covered batteries are at a disadvantage, as a hail of missiles will seek the gun-ports and conning-towers wherever an enemy, from the nature of circumstances, takes close quarters. Experiment abroad has also demonstrated that the projecting chase (forward body) of a large gun is extremely vulnerable, and liable to injury from the fire of the larger rapid-firing pieces.

"This system, which is just now so important an adjunct to the main battery of ships of war, is of but recent development. The first order received for a weapon of this kind by the Hotchkiss firm came from the United States, and the guns now mounted in the new ships *Boston*, *Atlanta*, and *Dolphin* were delivered under it. Three calibres were obtained, *viz.*, the 6, 3, and 1 pounder, as they are known in the United States navy, their usual names in other countries being the 57, 47, and 37 millimetre guns. Since their introduction the demand for larger calibres by most of the prominent naval powers has been so pressing that the Hotchkiss Company has produced a 9-pounder and has a 33-pounder in course of manufacture. It is believed that this last calibre represents about the limit of utility of the Hotchkiss system, though the gain in time by the use of ammunition carrying the charge projectile and fulminate in one case will recommend it for use with much larger calibres, even where two men may be required to handle the cartridge."

The most important trials of rapid-fire guns during the past two years are thus described by Lieutenant Driggs, United States navy:

"The various systems now in use, or being developed, are the Albini, Armstrong, Driggs-Schroeder, Gruson, Hotchkiss, Krupp, Maxim, Nordenfeldt. Of these the Armstrong has not been favorably received on account of the cumbersome breech-closing arrangement. This consists in two side levers attached to and turning about the trunnions; a cross-head connects the two levers, and by an eccentric motion one of them is pressed against or removed from the breech of the gun, thus closing or opening it. The *Bausan* has two of those guns, but with that known exception few, if any, have been put in service.

"The Gruson gun is said to be very similar to the Hotchkiss in its mechanism, though not as good. The Maxim and Hotchkiss are both well known. The Nordenfeldt, which in Europe is the greatest rival of the Hotchkiss, is entirely different from the guns heretofore made under this name. In the single-shot rapid-fire gun the breech is closed with a double breech-plug, which is revolved in the breech recess by a cam motion. The plug is divided transversely; the front half carries the firing-pin, and has only a circular motion in closing and opening; the rear half acts as a wedge, the first motion being downward and the second circular, the front half then moving with it.

"One of the most complete tests to which guns of this class have been subjected was that conducted by the Italian government in February of last year (1885). The trials were made at Spezia, the following being offered for test: Hotchkiss rapid-fire; improved Nordenfeldt rapid-fire on recoil carriage; Armstrong rapid-fire; and a rapid-fire gun made at the Government Works at Venice. The Armstrong gun was not fired; the others were fired in the following order: Nordenfeldt, Hotchkiss, and Italian.

"The guns were mounted on board a small ship (the *Vulcano*) for firing at sea. A large target was fixed on the breakwater in the middle of the harbor of Spezia, and two smaller targets of triangular shape had been anchored, one 550 yards inside, and the other 550 yards outside, the breakwater. The *Vulcano* was then placed 1300 to 1400 yards inside the breakwater, and fire begun against the large target with the Nordenfeldt 6-pounder gun, which was worked by Italian sailors. A first series of eighteen shots were fired in forty-seven seconds, for rapidity of fire with rough aiming. A second series of sixteen shots were fired in thirty-four seconds. The rapidity of fire with rough aiming and untried men was thus respectively at the rate of twenty-three and twenty-eight shots per minute. Afterwards, ten case-shots were fired with the gun almost level, in order to see how the lead bullets were spread over the range. Some of them were seen to touch the water 700 or 800 yards from the muzzle, and the whole range was well covered by the 150 lead bullets contained in each of the Nordenfeldt case-shots.

"The second part of the programme consisted of the firing at three targets, respectively at 600, 1200, and 1800 yards, the ranges being only approximately known, changing the aim at every third shot, and firing under difficulty, owing to the movement of the ship. Twenty-one common shells were fired, seven at each target, with good accuracy, and the shells on striking the water burst better at the shorter than at the longer ranges.

"The firing at sea was closed with one more series of ten rounds, fired rapidly in twenty-six seconds, in order to see if the gun would act well after being heated by the eighty-five rounds which had already been fired. Four of the last series were ring-shells, and burst on striking the water at the first impact, breaking into a larger number of pieces than the common shells. The Nordenfeldt gun was then mounted on shore for tests of penetration. The plates used were: (1) a $5\frac{1}{4}$-inch solid wrought-iron; (2) a 4-inch solid (Cammell) steel plate; (3) one $\frac{7}{8}$-inch steel plate, at an angle of fifteen degrees to line of fire. The two thick plates were backed by ten inches of oak, and at right angles to line of fire and one hundred yards from the gun. The perforation was in every case complete, both with solid steel shot and chilled-point shells, these latter bursting in the wood behind. The thin plate was then put at more acute angle to the line of fire, and only when this angle was seven degrees or eight degrees did the projectile fail to penetrate. The indicated muzzle velocity of this gun is 2130 feet, with a 6-pound projectile and charge of two pounds fifteen ounces.

"A few days afterwards the Hotchkiss gun went through the same trials and programme. For rapidity forty rounds were fired with rough aiming in three minutes, the rate being 13.3 per minute. The shooting was good, but the men serving the gun complained of being fatigued by the shocks from the shoulder-piece. The muzzle velocity was about 1085 feet, or about 300 feet below that of the Nordenfeldt. Last of all, the Italian gun was fired, but as it was designed for 1480 feet velocity, it was not brought in direct competition with the other two guns in power. The rapidity of fire obtained, however, was about twenty rounds per minute, and both the mechanism and recoil-carriage worked well.*

"The Hotchkiss and Nordenfeldt guns were tried in competition at Ochta, near St. Petersburg, in September last (1886). The reports that have reached this country are very meagre, but are unanimous in favor of the Nordenfeldt gun. From what can be learned, the fire was first for rapidity, in which the Nordenfeldt discharged thirty rounds in one

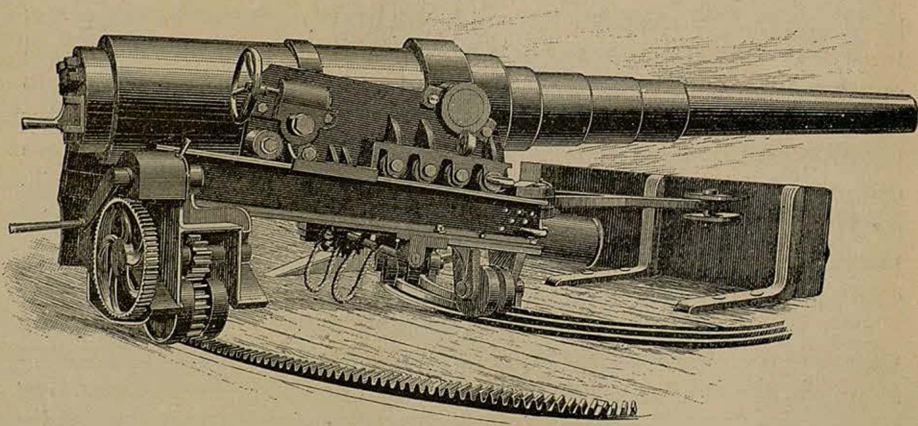
* From *Army and Navy Gazette*, February 27, 1886.

minute, and the Hotchkiss twenty rounds in the same time, the initial velocity of the former being 624 metres (2047 feet) per second, while that of the latter was 548 metres (1797 feet) per second.

"The fire of both guns was directed upon a target at 1800 metres (1969 yards) range. The Nordenfeldt scored nine hits, while the Hotchkiss made none. It is more than likely that this failure was due more to defective pointing than to any defect of construction.

"The trial closed with a very interesting and instructive experiment.

"Four targets were placed at 600, 800, 1000, and 1200 metres; each gun was to fire as rapidly as possible for thirty seconds, changing the range each fire, from the 600 up to the 1200 metre target and back. During this test the Nordenfeldt is said to have discharged fifteen shots in the thirty seconds, and to have made nine hits, while the Hotchkiss



NEW 6-INCH BREECH-LOADING RIFLE.

scored but two hits and only discharged eleven rounds in thirty-two seconds. Here again the element of inaccurate sighting may be largely responsible for the difference in the number of hits, but the great disparity in the number of rounds fired must be due to the mechanical defects in the Hotchkiss system by which the action of its breech-block is too slow. Notwithstanding the reported success of the Nordenfeldt gun in the trials, the Russian government ordered a number of Hotchkiss guns and no Nordenfeldts."

The latest experiments with large calibred rapid-fire guns were those of the Armstrong 36 and 70 pounder. The first piece differs materially from the new 33-pounder Hotchkiss; it is 4.724 inches in calibre, 14 feet 2½ inches length, and weighs 34 hundred-weight. It was fired with seven and a half pounds of powder ten times in forty-seven seconds, or at a rate six times faster than that obtained with the service guns of like calibre. The 70-pounder was fired with both twenty-five-pound and thirty-pound charges, at a speed of from eight to ten rounds per minute. In the latest mount for the 36-pounder the gun is supported on a rocking slide which pivots on transverse bearings, so that the piece moves only forward and backward on the slide; elevation and depression are given by a shoulder-piece attached to the slide, and the gun is secured at any desired angle with a clamp attached to the side of the slide.

This development of rapid-fire pieces opens anew the discussion as to the comparative values of large and small calibre guns. At the present stage of the question it is safe to say that, however necessary the large calibre may be in armored battle-ships and coast-defence vessels, its usefulness in thin-skinned, high-powered cruisers is questionable. Abroad, the long-range guns which constitute the primary batteries are being reduced in calibre, while the secondary batteries of rapid-fire guns are increasing so much in size that before the next sea-war a nearly uniform calibre of four or five inches will probably be established.

The reasons for these changes are not difficult to understand. In all sea engagements hereafter type will fight with type; that is to say, apart from the rôle which auxiliary rams and torpedo-boats may play, armored ships will oppose armored ships, and unarmored cruisers and gun-boats will, when intelligently handled, seek action only with vessels of similar character. To-day every unarmored ship afloat or under construction can be penetrated at the average fighting distance by a musket-bullet impelled with a little more than the ordinary velocity; and as there is absolutely no protection, it seems a mistake to arm such vessels with the unnecessarily large calibres now in use. Especially is this true when their employment is based mainly upon the remote assumption that such ships may have to attack fortifications. Smaller guns will do the work equally as well, if not better; for the greater intensity of fire secured by the certain action of a large number of easily handled small-calibred guns is surely more valuable than any probable advantage which might be derived from heavier projectiles fired under conditions that make their effectiveness doubtful.

Whatever may be said to the contrary by mere theorists, the difficulty of handling ordnance increases enormously as the calibres grow; and sea-officers, who alone are the proper judges, insist that the monster pieces of the present day are so unmanageable as to be nearly useless. Of course, where armor penetration is vital to success, heavy armaments must and will be employed; but when this factor need not be considered, a great many light guns, easily worked by hand, are the demands of the hour. The problem, fortunately, is nearer solution owing to the development now in progress; and when this is coupled with the rapidly increasing popularity of the 5-inch breech-loading all-steel rifle, our country notably may congratulate itself that ordnance is reverting to a plane which other nations mistakenly and at great cost abandoned, and which the United States can readily attain.

SHIPS OF THE MINOR NAVIES.

EARLY in September of this year there sailed from England for the East five Chinese war-vessels of the latest types: the *Chih Yüan* and *Ching Yüan*, fast cruisers; the *King Yüan* and *Lai Yüan*, coast-defence ships; and a torpedo-boat as yet unnamed. Though the squadron was commanded by Admiral Lang, a captain in the Royal Navy temporarily serving under the Chinese government, the other officers were mainly, and the crews were wholly, natives who had passed through English cruising and training ships. The *Chih Yüan* was commanded by Captain Tang, who had under him nine English and fifteen Chinese officers and one hundred and fifty men; the *Ching Yüan* was in charge of Captain Yih, and eleven English and fourteen Chinese officers, with the same complement; while the other ships were officered and manned much the same way. There was, it is true, an English fleet surgeon, but each ship had its native medical officer and two chief engineers, one of whom was a Chinese. "On leaving Spithead," stated the *Herald* cable despatch, "the fleet will proceed direct to Gibraltar, thence to Port Said, where it will take in coal; it will stop at Suez, Aden, Colombo (where it will coal again), Singapore, Hong-Kong, Chefoo, and Taku, joining at this place the fleet already assembled under Admiral Ting, and replacing there many of the foreigners by native officers. The voyage is expected to occupy seventy-two days—fifty-two at sea and twenty in harbor—and during this time the crews will be thoroughly practised in torpedo, gun, and other drills. This, of course, will involve a deal of hard work, such as would try the endurance of English sailors, but the Chinamen will be allowed a plentiful supply of beef and beer."

Modern cruisers and armed battle-ships requiring the highest intelligence to fight, torpedo-drills, beef and beer—and all for that outer barbarian whom our mobs murder just for a lark! Here is a lesson for Congressmen; here an example and a possible menace for this defenceless land.

The Chinese navy, though of recent growth, consists to-day of seven armored and ten unarmored ships of modern types, in addition to torpedo-boats, and to at least thirty other vessels which are not so obsolete as nine-tenths of the ships this country has in commission.

Nearly ten years ago the Chinese government realized that its wooden corvettes, gun-boats, and armed junks were no longer adapted to warfare, and ordered from the Vulcan Works at Stettin the two steel cruisers *Nan Shu* and *Nan Shen.* These are of 2200 tons displacement, and with 2400 horse-power have developed 15 knots speed; their armament is composed of two 8-inch and eight 4½-inch Armstrongs, and of lighter secondary pieces. In 1881 these ships were followed by the armored battle-ships *Chen Yüan* and *Ting Yüan*, and by the steel cruiser *Tchi Yüan.* The battle-ships are built of steel, and have the following dimensions: length 296.5 feet, beam 59 feet, mean draught 20 feet, displacement 7430 tons. Their compound armor extends throughout a central citadel 138 feet long, and around a nearly elliptical redoubt situated at its forward end; the side armor is five feet wide, and has a thickness of 14 inches at the water-line, of 8 inches at the lower and of 10 inches at the upper edge; the protection to the redoubt is 12, and to the conning-tower 8, inches thick. The armament consists of four 12-inch Krupps, echeloned in pairs within the redoubt; of two 5.9-inch Krupps mounted forward and aft inside of machine-gun proof turrets; of eleven Hotchkiss revolving cannons, and a supply of Whitehead torpedo-tubes. The engines are of the three-cylinder compound type, and develop 7300 horse-power and 15.5 knots. The ships have double bottoms, minutely subdivided, and in addition to a cork belt forward and abaft the citadel a steel protective deck two inches thick curves to the extremities. The twin-screw steel cruiser *Tchi Yüan* is of 3200 tons displacement, and has two sets of two-cylinder horizontal compound engines, which develop 2800 horse-power and a speed of 15 knots; her dimensions are: length 236 feet 3 inches, beam 34 feet 5 inches, and draught 15 feet 9 inches. The entire under-water body is covered by a curved steel deck, which is 4 inches thick, and extends 4 feet 9 inches below the water-line; the space between this deck and the one above is used for coal-bunkers. "There are two machine-gun proof turrets on the fore and aft line, the base of the forward one being surmounted by a fixed tower armored with 15-inch steel, which extends to a height sufficient to protect the base of the turret, its machinery, and gun-carriages. The armament is composed of two 8.27-inch (21 centimetre) Krupps in the forward turret, of one 5.9-inch (15 centimetre) Krupp in the after turret, of two similar guns on the main deck aft, of five Hotchkiss revolving cannons, and of a supply of Whitehead torpedes, discharged through four above-water tubes." *

The swift protected cruisers *Chih Yüan* and *Ching Yüan* were built at Elswick; the unnamed torpedo-boat is of the *Yarrow* type; and the coast-defence vessels *King Yüan* and *Lai Yüan* were constructed at Stettin. The displacement of the cruisers is 2300 tons, length 268 feet, beam 38 feet, depth 21 feet, and draught 14 feet forward and 16 feet aft. Each vessel has two pairs of triple-expansion engines. Both the engine and boiler rooms are divided into water-tight compartments by transverse and longitudinal bulkheads, and the machinery is so arranged that either boiler can work on one engine or on both, and the change necessary to effect this can be made while the vessel is in motion. The result of this intercommunication between each engine and each boiler is that the vessel can proceed so long as any single boiler and engine are uninjured.

In the four trial trips, two with and two against the tide, with all their weights, armament, and Chinese crews on board, they attained an average speed of 18.536 knots.

The vessels are built of steel, and have two decks, the lower one consisting of four-inch steel plates, rising in the middle above the water-line and inclined at the sides so as to dip below it. The engines, magazines, rudder-head, and steering gear lie below, and are protected by this deck. The openings in the deck are encircled by coffer-dams, armored with steel plates, inclined so as to deflect projectiles. The bows are formed and strengthened for ramming purposes. Additional protection is given to the vessel by a partition which is built on the protective deck parallel to the side of the ship; this encloses a space that is eight feet wide, and is subdivided into a great number of water-tight compartments for the stowage of four hundred and fifty tons of fuel. Both ships have double bottoms, minutely subdivided into water-tight compartments.

The armament consists of three 21-centimetre Krupp guns—two mounted forward and one aft—all on centre-pivot, shield-protected Vavasseur carriages; of two 6-inch Armstrongs on sponsons, also Vavasseur mounted; of eight 6-pounder rapid-fire Hotchkiss; and of six Gatling guns. There are four above-water torpedo-tubes—two fixed (one in the bow, firing ahead, and one aft, pointed astern) and two training, one in each broadside.

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* Lieutenant Colwell, United States Navy.

There are two electric search-lights for each vessel, with a nominal power of 25,000 candles, while the cabins and rest of the ship are lighted with incandescent lamps.

"It is humiliating," writes the *Army and Navy Gazette*, "but nevertheless an actual fact, that two of the cruisers of the Chinese squadron under command of Admiral Lang are superior in certain novelties of construction to any of our own vessels of this class. In point of speed the two unarmored ships which have been turned out by the Elswick firm cannot be touched by our swiftest cruisers. They steam nearly nineteen knots an hour. The traversing and manipulation of their guns can be effected with such rapidity that when saluting the garrison at Portsmouth recently it appeared almost impossible that the guns could have been properly sponged between each discharge, the two bow guns especially keeping up a continuous roar. Only the two sponson 6-inch guns are from Armstrong's; they are mounted on Vavasseur carriages, and fitted with singularly simple breech apparatus. The other three heavy guns are Krupp's 21-centimetres (about 8¼-inch). These last are protected with a shield of entirely unique construction. It is of steel, and commencing from the trunnion ring spreads out into a wide shelter sufficient to accommodate the entire gun detachment. The sights are also under cover. The stern-chaser has a single shield; the two bow-chasers are included within one. The torpedo apparatus is most complete. In addition to the two tubes opening ahead and astern, which are well above the surface of the water, there are six others in connection with the torpedo-room.

"But the latest improvement which is observable on board is the steel armored conning-tower, fitted with Lord Armstrong's patent telegraph and communications, for which a special royalty of four hundred pounds has to be paid. It is the most perfect scheme for conducting fighting operations that has ever come under our notice. A model for laying all the guns is prominently placed in front of the steering-wheel, which is under personal command of the officer in charge. On the left are tubes and telegraphs by which he can converse with the officer in command of the gun detachment, and correct any mistakes observable in the laying of the guns. Then he can fire simultaneously, if desirable, or singly, if preferred. All stations on board are also in communication with this conning-tower. Hence the entire fighting power of the vessel, torpedoes and all included, is at the disposal of the officer in command within the conning-tower. Another useful modification has been effected in these vessels. The conning-tower, which is at the foot of the foremost fighting mast, has close to it the signal station, also protected with steel armor, so that the signaller therein is absolutely secure, and close to the commanding officer, from whom he receives and to whom he communicates outside signals."

The torpedo-boat built by Yarrow is said to be the fastest of its size that has ever been launched, as it has reached a speed of about twenty-eight knots an hour. It is armed with two fixed 14-inch torpedo-tubes in the bows, and one 14-inch training-tube on deck abaft the funnel. It is also supplied with a powerful armament of Hotchkiss and Gatling guns, and a strong electric search-light so arranged as to be worked either from the conning-tower or from the deck.

The *King Yüan* and *Lai Yüan*, built by the Vulcan Company at Stettin, are powerful vessels, effective for either coast defence or distant sea service. Their principal dimensions are: length 269 feet, beam 39 feet 4 inches, depth 25 feet 6 inches, mean draught 16 feet 8 inches, and displacement 2900 tons. They are built entirely of steel, with double bottoms extending two-thirds of the length, and the under-water body is divided by bulkheads into sixty-six water-tight compartments. The armor protection is compound, and consists of a belt six feet wide extending the length of the machinery and boiler space, having a maximum thickness of 9.5 inches at and above the water-line, and a minimum thickness of 5.1 inches. This belt is terminated at either end by thwartship armored bulkheads, 5.1 inches thick. At the forward end of the belt is a circular revolving turret eight inches thick, on top of which is the conning-tower, with an armor protection of six inches. The under-water body is protected by a complete steel protective deck, 1.5 inches thick over the top of, and three inches thick forward and abaft, the belt. A partial cork belt above the protective deck gives additional stability. The engines consist of two sets of three-cylinder compound type, situated in two separate compartments, driving twin screws, and developing 3400 horse-power with forced draft. The boilers, four in number, are placed in two separate compartments. A speed of about sixteen knots was attained. The armament consists of two 21-centimetre (8.27-inch) Krupps mounted in the turret; of two 15-centimetre (5.91-inch) similar guns carried in recessed ports; of two 47-millimetre Hotchkiss rapid-fire guns; of five 37-millimetre revolving cannons; and of four torpedo-discharging tubes—three above-water and one in the bow below the water-line.*

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* Naval Intelligence, General Information Series No. 5.

As additions to the lightly armored gun-boat *Tiong Sing*, built in 1875, China ordered this year from the Vulcan Company two heavy coast-defence vessels of 7000 tons displacement and 6000 horse-power, and laid down at Foochow an armored gun-vessel. The *Tshao Yong* and *Yang Wai* are steel cruisers built at Elswick, of 1350 tons displacement and 2400 horse-power; they have developed sixteen knots, and are armed with two 10-inch and four 4½-inch Armstrongs, with a secondary battery of two lighter pieces and six machine guns. The *Fee-chen*, a small steel cruiser built at Sunderland, England, has triple-expansion engines, and is expected to develop thirteen knots. Her armament consists of two 6-inch Armstrongs and four lighter guns; she is also fitted to do cable work. Three cruisers of the *Nan Shu* type are being constructed in Chinese dockyards, besides several of the *Kuang Chen* class of gun-boats.

The Japanese navy consists of forty vessels, of which eight only are modern. The classified armored fleet includes five ships, among them the *Adsama Kan*, formerly known as the *Stonewall Jackson;* none of these is of any importance except the central battery ship *Fu Soo*, which was launched in 1877. In January of this year, however, the Japanese government ordered from the Société des Forges et Chantiers de la Méditerranée two coast-defence vessels, to be built on the plans of M. Bertin, constructing engineer of the Japanese navy. They are to be built entirely of steel, on the cellular plan, with two longitudinal and twelve transverse bulkheads. Their principal dimensions are: length 295 feet 2 inches, beam 50 feet 6 inches, depth 34 feet 9 inches, draught aft 21 feet 2 inches, displacement 4140 tons. The armament proposed is one 12.6-inch (32-centimetre) breech-loader, eleven 4.72-inch (12-centimetre) breech-loaders, six rapid-fire guns, twelve revolving cannons, and four torpedo-tubes—one in the bow, one in the stern, and one each broadside. Two independent triple-expansion engines, driving twin screws, and required to develop 5400 indicated horse-power with forced draft, and 3400 with natural draft, supplied with steam by six three-furnace boilers in two groups, furnish the motive power. The estimated maximum speed is sixteen knots. A heavy protective steel deck and a complete surrounding arrangement of coal-bunkers protect the engine and boiler space and magazines. The complement of officers and men will number four hundred. In March, 1887, a small armored gun-vessel, designed by the same official, was laid down at the Ishikawa-Shima dockyard, Japan. The displacement is 750 tons, length 150 feet, and beam 25 feet.*

* "Recent Naval Progress."

Of the unarmored vessels, the sister-ships *Naniwa Kan* (already described) and *Takatschio* are at present the most important, though six modern cruisers now under construction in Japanese dockyards will soon be added to the fleet. The navy is manned and officered exclusively by natives, and the service is well administered and popular. Owing to possible complications with China, coast defence has become a live national question, and the wealthy Japanese are subscribing large sums for ships and forts. In addition to these voluntary contributions, the new tax which has been imposed will enable Japan to put herself in an excellent condition for attack or defence.

The other navies not described in these pages have afloat or under construction but few modern ships-of-war. Still, there are vessels in the minor services which ought to be briefly described. One of these, the *Almirante Brown*, of the Argentine navy, is a twin-screw, central-battery steel ship which was launched in 1880. Her dimensions are: length 240 feet, beam 50 feet, draught 20 feet 6 inches, and displacement 4200 tons. With 4500 horse-power she attained 13.75 knots, and her coal endurance is given as 4300 knots at 10 knots speed. Her armament is made up of eight 8-inch and six 4½-inch Armstrongs, and of four machine guns; the armor is compound, nine inches thick on the belt and eight inches on the battery. There is also building in England for this government a central casemate steel cruiser of 4400 tons displacement. The armor on the casemate is to be compound, ten inches thick, and the armament is to be composed of eight 8-inch breech-loading Armstrongs, with a secondary battery of rapid-fire guns and torpedo-tubes. The estimated speed is fourteen knots. In addition to these two vessels the Argentine navy has two small coast-defence turret-ships, one 14-knot steel cruiser (the *Patagonia*, which is similar in appearance to the United States steamer *Atlanta*), six gun-boats, eleven torpedo-boats, and a few other vessels of an unimportant character.

The Brazilian navy has, exclusive of her capital torpedo-boat flotilla, over fifty vessels, of which a dozen are classed as armored. These last are mainly medium draught, coast-service turret-ships and river monitors, though among them are the *Riachuelo* and *Aquidaban*, twin-screw armored cruisers, and the *Solimoes*, an armored battle-ship. The *Riachuelo* made a sensation when she first appeared, and is still one of the most formidable vessels in the world. She is built of steel, and has the following dimensions: length 305 feet, beam 52 feet, draught 19 feet 6 inches, displacement 5700 tons. Her armor is compound, eleven inches thick on the belt and ten inches on the turret, conning-tower, and redoubt. She has also a steel deck, which curves forward to strengthen the ram, and aft to protect the steering gear. Her armament consists of four 9-inch 20-ton Whitworths (Armstrong altered) mounted in two echeloned turrets, and of six 5½-inch guns carried under cover in the superstructure. Her secondary battery includes fifteen machine Nordenfeldts and five above-water torpedo-tubes. With 7300 horse-power she attained a speed of 16.71 knots, and is credited with a coal endurance of 4500 miles at 15 knots speed.

The *Aquidaban* is of the same type and general appearance as the *Riachuelo*, but of smaller dimensions. Her length is 280 feet, beam 52 feet, draught 18 feet, displacement 4950 tons. The compound armor is from seven to eleven inches in thickness, and seven feet in width on the water-line belt, and is ten inches thick on the conning-tower and on the oval redoubts which protect the bases of the two echeloned turrets. The armored deck and redoubt roofs are built of steel, from two to three inches thick. The armament consists of four 9-inch 20-ton guns mounted in the turrets, and of four 70-pounders carried under the superstructure. The secondary battery is made up of fifteen 1-inch Nordenfeldts and five above-water torpedo-tubes. She developed on trial 6251 horse-power and a speed of 15.81 knots, and made on the voyage from Lisbon to Bahia 3600 knots in 13 days and 17 hours, and from Bahia to Rio Janeiro 750 knots in 2 days and 20 hours. The average speed for the passage from England to Rio was nearly eleven knots on a daily coal consumption of forty-three tons.

The Chilian navy has the two iron-armored, twin-screw, central-battery ships *Almirante Cochrane* and *Blanco Encalada*, and the lightly armored turret-ship *Huascar*. The *Almirante Cochrane* and *Blanco Encalada* are 210 feet in length, 45 feet 9 inches in beam, 19 feet 8 inches in draught, and 3500 tons in displacement. The former carries four 9-inch and two 7-inch breech-loading Armstrong rifles, four lighter pieces, and seven machine guns. Before the alterations and repairs lately made, the *Blanco Encalada* had six 12-ton muzzle-loading Armstrong rifles, four lighter pieces, and seven machine guns. The *Huascar* was built in 1865, and is a slightly protected iron ship of 2032 tons displacement, 1050 horse-power, and 12 knots speed. Her battery consists of two 10-inch muzzle-loading Armstrongs and two 40-pounders. Her wonderful record on the west coast of South America has made her name as familiar in the mouth as a household word, and whatever may have been the justice of the war, there never can or will be a question of the superb courage with which she was fought by her gallant officers and crew.

Chili has three wooden corvettes, the *Chacabuco*, *O'Higgins*, and *Pilcomayo*, one composite corvette, the *Magellanes*, one steel cruiser, the *Esmeralda*, five gun-boats, two paddle steamers, one despatch-boat, one transport, and eleven torpedo-boats. In April, 1885, The *Esmeralda* ran from Valparaiso to Callao, 1292 miles, in one hundred and eight hours, the engines during the last eight hours barely turning over. In the exhaustive trials made before her departure from England the highest speed attained was 18¼ knots per hour. The *Esmeralda* is said to be at present in an inefficient condition, both as regards her speed and battery power. In November, 1886, the Chilian government gave the Armstrong firm an order for a powerful, partially-protected steel cruiser, which is to be of 4500 tons displacement, and to develop 19 knots speed. Her armament is to consist of two 10-inch, one 8-inch, and two 6-inch Armstrong breech-loaders, with a secondary battery of four 6-pounder rapid-fire guns, eight Hotchkiss revolving cannons, and eight torpedo-tubes. The cost of this vessel is to be about $1,500,000.

APPENDIX I.

SUBMARINE WARFARE.

THE practicability of submarine navigation was established by the Dutch over two hundred and fifty years ago. Then, as now, its underlying idea, its claim for recognition, was the advantages the system gave in marine warfare. Nor is its battle value overestimated; for such a boat, if successful, exercises an influence that is great in material uses, that is enormous in moral effects. Its development has been slow; for though the problem was solved long ago, no practical results were attained until within the last thirty years. During the late war submarine boats were for the first time employed with such sufficient success that the great maritime powers have considered the type to have an importance which justified investigation. They reached this conclusion because no plan of defence exists which could defy the operations of a weapon that attacks not only matter but mind.

There is no danger which sailors will not face; because their environments are always perilous, and their traditions are rich with glorious records of seeming impossibilities overcome by pluck and dash. They are willing always, even against the heaviest odds, to accept any fighting chance. They know that the unexpected is sure to happen. The spirit that made Farragut take the lead of his disorganized line in Mobile Bay still lives; his clarion call of "Damn the torpedoes! Follow me!" is a sea instinct, born of brine and gale, which never dies.

Whatever coast fighting or port blockading may demand, sea battles are unchanged. History teaches that ships always closed for action, and that vessels fighting each other from beyond the circling horizons, or hull down, with long-range guns, are the dreams of shore inventors. Guns and ships have changed, but men and the sea are changeless. The fighting distance of to-day is not much greater than it was in Nelson's or in Perry's time; and the next naval war will surely prove that battle will be nearly as close as in Benbow's age, when the gallant tars combed innocuous four-pound shots out of their pigtails, and battered each other within biscuit-throwing distance with deftly shied chocking quoins.

It is fortunate, in the interest of good, square fighting, that the operative sphere of submarine boats is limited to coast work. Fortunate, because while the bravery and the grit are the same, the threatening of a danger which cannot be squarely met is apt to benumb the heart of the stoutest. A sailor hates to run; he does not care to fight another day when the chance of the present is open before him; but of what avail are the highest courage and skill against a dull, venomous dog of an enemy who crawls in the darkness out of the deeps, and, silently attaching a mine or torpedo, leaves his impotent foe to sure destruction?

Submarine mines may be countermined; when necessary, defied; guns may be silenced and torpedo-boats so riddled by rapid-fire guns that they will be disabled beyond the radius of their effective action; automatic torpedoes may be checked by netting, or by the prompt manœuvrings of the attacked vessel; ship may always fight ship. But what is the chance for brain or brawn against a successful submarine boat, when the mere suspicion of its presence is enough in itself to break down the blithest, bravest heart of oak. It is here that their moral effects are enormous.

The history of their development may be briefly told. In 1624 Cornelius Van Drebble, a Hollander, made some curious experiments under the Thames. His diving-boat was propelled by twelve pairs of oars and carried a dozen persons, among them King James I. In 1771 Bushnell, of Connecticut, constructed a boat which Washington described in a letter to Jefferson as being a "machine so contrived as to carry the inventor under water at any depth he chose, and for a considerable time and distance with an appendage charged with powder, which he could fasten to a ship, and give fire to it in time sufficient for his returning, and by means thereof destroy it." Fulton borrowed Bushnell's idea, and in 1801 experimented successfully with it in the Seine. He descended under water, remained for twenty minutes, and after having gone a considerable distance, emerged. In 1851 a shoemaker named Phillips launched in Lake Michigan a cigar-shaped boat forty feet long and four feet in its greatest diameter. This was his first attempt, but in the course of a few years he so far perfected his arrangements for purifying the air that on one occasion he took his wife and children, and spent a whole day in exploring the bottom of the lake. In the history of these boats, as told in the report of the Board on Fortifications, Phillips afterwards descended in Lake Erie, near Buffalo, and never reappeared.

Many other attempts were made, the most successful being that of a Russian mechanic, who in 1855 built a diving-boat which was under such perfect control that he could remain submerged for eight hours. The boat which sank the *Housatonic* was a remarkable submarine vessel; it was about thirty-five feet long, built of boiler iron, and had a crew of nine men, of whom eight worked the propeller by hand, while the ninth steered and governed the boat. She could be submerged to any desired depth or could be propelled on the surface. After various mishaps she went out of Charleston harbor, attacked and sank the United States steamer *Housatonic*, then on blockade duty; as she never returned, it is supposed that the reflex action of the torpedo destroyed her.

In the report quoted above the results already attained in submarine navigation are thus summarized by Captain Maguire, U.S.A.:

1. Submarine boats have been built in which several persons have descended (with safety) for a great distance below the surface of the water.

2. Submarine boats have been propelled on and under the surface in all directions.

3. The problem of supplying the necessary amount of respirable air for a crew of several persons for a number of hours has been solved.

4. Steam, compressed air, and electricity have been used as the motive power.

5. The incandescent electric light has been used for illuminating the interior of submarine boats.

6. Seeing apparatus have been made by which the pilot, while under water, may scan the horizon in all directions.

7. A vessel has been in time of war destroyed by a submarine boat. The latter, it is true, was also sunk, but it was for reasons that are no longer in force.

As yet no perfectly successful boat of this type has been tried in any naval war, but there is no question that they will be used at the very first opportunity. Compared with a surface boat, the submarine has the following advantages:

1. It does not need so much speed. The surface boat demands this quality so as to get quickly within striking range of its torpedo, and then to escape speedily out of range of machine guns, etc.

2. Its submersion in the presence of the enemy prevents the engines being heard.

3. There is no smoke nor glare from the fires to cause its detection.

4. The boat and crew, being under water, are protected from the fire of machine guns and rifles.

5. It is enabled to approach the enemy near enough to make effective even an uncontrollable fish torpedo.

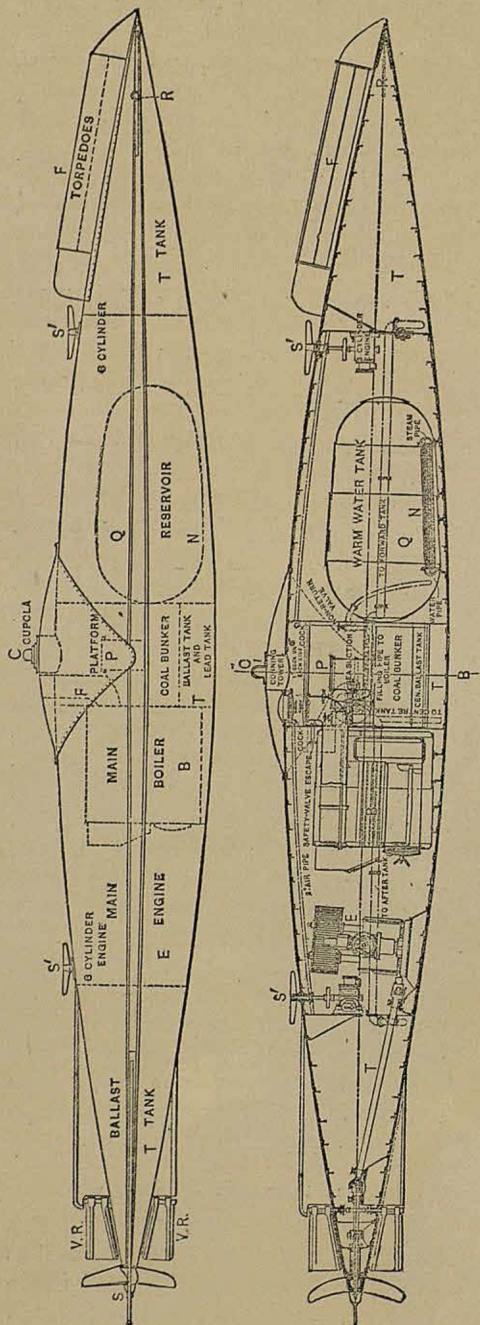
6. It can be used with safety as a reconnoitring or despatch boat.

7. It can examine the faults in the lines of submarine mines, and replace mines exploded in action. Abroad, the Nordenfeldt boat has awakened the most interest, and here the American submarine monitor holds the first place.

The form of the Nordenfeldt boat is that of a cigar or of an elongated cylinder tapering away to a fine point at each end. The outer case, built of stout steel, is calculated in its construction to resist such a pressure as would enable the boat to descend even beyond a depth of fifty feet, although that is set as the maximum for its diving operations. The cigar shape does not at first sight commend itself, even in the eyes of nautical men, on account of its supposed tendency towards a rolling motion. The experience, however, gained with the boat exhibited for the benefit of naval experts at Carlscrona, in September, 1885, has shown that very good sea-going qualities can be developed in a craft built upon such lines; for this small vessel has weathered more than one gale in the Baltic, to say nothing of the severe storm it encountered at the entrance to the Kattegat when proceeding from Gottenburg to Copenhagen for the experimental trials.

This quality results from the fact that each end of the boat forms a tank, which is filled with water, and as there is no extra buoyancy in those directions, and consequently no tendency to lift at those parts as with an ordinary vessel in a sea-way, the vessel rises and falls bodily instead of pitching. It has been found that by going at a moderate speed and taking the seas a point or so on the bows the boat makes very good weather, as the waves, breaking on the snout, sweep over the fore part and expend their force before any portion of them can reach the central section.

Steam, which is employed as motive power, is perfectly trustworthy as an agent. There is nothing about its action, or the appliances connected with it, that is beyond the grasp of an ordinary engineer, whereas such can hardly be said as yet in respect either to electricity or the other agencies by which inventors have sought to obtain motion. The difficulty, however, has always been how to retain



LONGITUDINAL PLANS OF NORDENFELDT BOAT.

steam pressure for any great length of time without carrying on combustion. This in the Nordenfeldt boat is secured in the following ingenious manner: A large reservoir or hot-water cistern (marked Q in the plate) is placed in the fore part of the boat, in communication with the boiler. The steam from the latter passes through a number of tubes in the reservoir N, thus raising the temperature of its contents until the pressure stands at the same degree in both. While the boat is at the surface, the maximum pressure once attained, as long as combustion is carried on, supplies quite enough steam both for driving the engines at full speed and for maintaining the contents of the cistern in the proper superheated condition. When the boat is submerged and the furnace doors are closed combustion ceases, and the steam given off by the hot water in the boiler and cistern is sufficient to keep the engines going for several hours.

Submersion to the various depths required is secured by the motion of the vertically acting screws, S S, driven by small three-cylinder engines. The boat is so ballasted as always to have spare buoyancy, and while a few revolutions of the screws will send her under water, the arrest of their motion is all that is required to bring her to the surface again. In this arrangement, as even the non-technical reader will readily understand, there is a great element of safety, the rising motion being entirely independent of any machinery which might refuse to act at the required moment. Another advantage is also gained in the ease with which the horizontal position is maintained by regulating the speed of the screws. To assist in keeping this position there is a horizontal rudder or fin, R, at the bows, which, by a very ingenious arrangement of a plumb weight with other mechanism in connection with the steering tower, works both automatically and by hand. The torpedoes are carried on the outside of the boat, as shown at F. They are Swartzkoph or Whitehead, as the case may be, and are released by electrical action under the control of the captain, standing on the platform at P. C is a cupola of stout glass by which a view is obtained occasionally when the boat is running submerged.

Construction Details.—The following are the dimensions of the Turkish boat: length 100 feet, beam 12 feet, displacement 150 tons, speed 12 knots, and coal endurance sufficient for travelling 900 miles. The engines (E) are of the ordinary inverted compound surface condensing type, with two cylinders, and with 100 pound pressure indicate 250 horse-power. The circulating and air pumps being actuated by a separate cylinder, the main engine is left free to work or not, while a vacuum is always maintained to assist the various other engines with which the boat is fitted. In this respect it should be mentioned that all the engines are specially designed with such valve arrangements as will make the utmost use of the vacuum, it having been found that while the boat is running beneath the surface as much power can be developed below the atmospheric line as above it.

The boiler, B, is of the ordinary marine return-tube type, with two furnaces, and the heating surface is about seven hundred and fifty square feet. The tanks at each end of the boat contain about fifteen tons each, and there is a third of seven tons capacity at the bottom of the central compartment for regulating buoyancy. The coal is stored around the hot-water cistern as well as at the sides of the boiler and over the central ballast tank.

Three men and the captain can efficiently work this boat, although she may carry a crew of seven, who could remain in her for over seven hours beneath the water without experiencing any difficulty in respiration. No attempt is made as in some systems to purify the atmosphere by chemical means, as it is said to be quite unnecessary.

The Practical Management.—The boat is operated in the following manner: Steam having been raised to the required pressure, the funnel is lowered, and water is let into the ballast tanks to bring the craft down to the proper trim for action. In this condition the screws, S S, are sufficiently under water to obtain the requisite thrust. The boat may still proceed at the surface for some time if the enemy be distant, but the conning-tower should be closed, and the cupola hatch and the furnace doors shut, before there is any chance of discovery. The vertically acting screws being started, the boat is then submerged to the cupola, and continues approaching until, according to circumstances, it becomes prudent to disappear entirely. The direction is taken at the last moment, and maintained by compass until within striking distance, when a torpedo is released, and the boat immediately turns in another direction.

In May of this year there was launched at Barrow a Nordenfeldt boat 110 feet in length and 13 feet in diameter. The engines are capable of developing good power, and a speed of 12 knots on the surface was realized. The boat was tried on the Bosporus during July under government supervision, and as these were satisfactory, it seems likely that a number of similar vessels will be built next year for the Ottoman navy.

The original submarine monitor *Peacemaker* is well known through its trials on the Hudson River in 1886, but since then so many improvements have been made in the direction of increased efficiency that it is confidently expected the boat just designed will surpass its former successes. It must be understood in the beginning that its essential principle remains the same, all the important improvements being the outgrowth of the experience gained in previous experiments.

Broadly defined, the new craft has a midship section, which through its high centre of buoyancy and low centre of gravity gives great stability of form, or, to make it plain to the non-technical reader, it differs from the ordinary cigar and tortoise shaped boat in being more nearly like the section of a pear, the apex of which forms the keel. Its longitudinal section is not unlike the form generally used, though the lines are such as have been found to give the form of least resistance and the highest speed.

It is built of steel, with frames and spacings sufficient to stand the pressure of the lowest depth to which the boat is or can be expected to go. The old dimensions were: length 30 feet, depth 7 feet, and beam 8 feet. In order to obtain increased speed the present vessel will be 50 feet in length, 8 feet in beam, and 8 feet in depth, with a displacement of from thirty-five to forty tons, or an amount sufficient to carry the weights of the interchangeable boiler, of the sixty horse-power engine, and of the provisions and fuel necessary for a surface cruise of one week, and, when necessary, for a constantly submerged cruise of twelve hours.

The advantages claimed for the new boat are that she is so self-sustaining as not to need the assistance of any other vessel; that she is not an accessary, but has in herself all essentials of defence; and that she answers all possible necessities for submarine work of any kind whatever, whether in peace or war. The increased speed will, it is hoped, give her power to attack modern vessels under way. When submerged, as was proved last summer, she sent no bubbles of air to the surface, and had neither a wake nor a wash to militate against the possibilities of an absolutely secret attack. Besides these advantages, the boat is said to be a safe surface-cruising vessel, forming no target for the destructive action of an enemy's attack, and at the same time having a capacity for disappearing so readily under water and avoiding the possibility of discovery that the enemy will be unable to tell when, where, or how the assault upon him may be made.

As in a former trial an accident proved the danger of an exposed conning-tower, the Submarine Monitor Company have provided a fin or guard for protecting the new helmsman's lookout and companion-hatches. The waterlock appliance employed in the original boat has now an additional use in supplying a mode of egress and ingress, the opening being made telescopic, so as to permit surface runs in comparatively rough water. When submerged, the smoke-stack acts telescopically, and is closed with a water-tight valve. To avoid the necessity of divers going out of the boat when under water, there are various openings at places in the exterior skin to which rubber sleeves or arms, with a radius sufficient to cover almost all practical necessities, will be fitted. These apertures do not constitute planes of weakness or danger, because they are normally closed by stout water-tight deadlights.

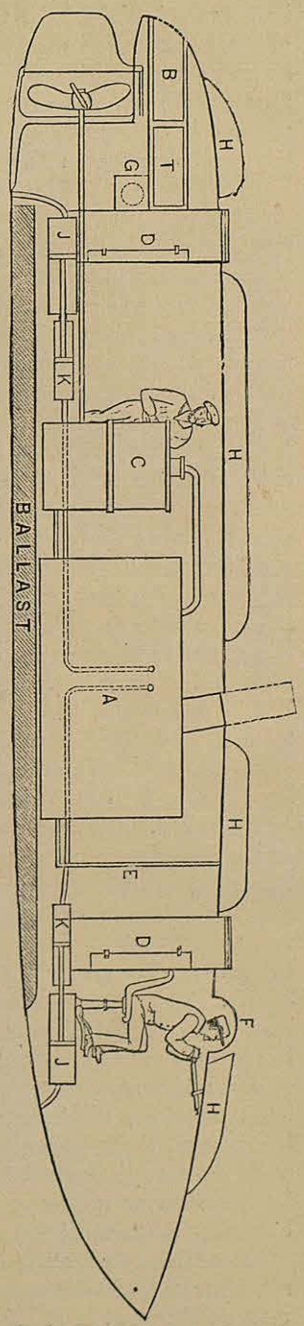
The Westinghouse engine is employed, as its construction prevents, by the packing used, any radiation of heat and the consequent elevation of temperation below. The air-tight doors and bulkheads work laterally, and the conning-dome is made of steel, with such apertures as will enable the helmsman to have, when on the surface, an all-round view, and when submerged, a sufficient light to let him in the daytime read, at a depth of thirty feet, the time by his watch.

Should the necessity arise, when submerged, the purity of the atmosphere below is preserved by passing the air through caustic soda, thus eliminating carbonic acid gas, and by reinforcing the loss of oxygen from tanks of compressed air. In the original experiments the boat was frequently submerged six hours at a time, and the crew of two men had no other air supplied than that which the boat carried down with her.

Besides these chemical means there are rubber tubes floated by buoys, with nozzles which protrude above the wash of the surface water. There is in each tube an automatic valve, which prevents water coming through the pipe at the time the air is being pumped in, and the depth below the surface to which outside air can be supplied is limited only by the length of the pipe.

In the plate, A represents a patented interchangeable boiler, in which either hydro-carbonate fuel or caustic soda can be used, in both cases steam being the motive power. The interior boiler for the use of the caustic soda is surrounded by a jacket, into which the steam exhausted from the engine can be used before it becomes so saturated as to create a back pressure on the engine, that is, for a period of twelve hours. When this

THE SUBMARINE MONITOR "PEACEMAKER."



limit is attained, and the surface is reached, the soda can be blown off into an outer receptacle provided for the purpose, and then reheated and recharged. The hydro-carbon fuel is ordinary mineral oil, carried in tanks of sufficient capacity for a surface run of a week. It may be emphasized as an important fact that this method of exhausting into the jacket of the boiler avoids the possibility of any bubbles appearing on the surface, as was notably the case with the earlier Lay boats.

Before diving, the caustic soda, which has been already heated by the combustion of the oil to the proper degree, acts in place of the ordinary fuel, thus constituting a sort of perpetual motion, until the point of saturation is reached, and back pressure in the engine results.

The boat, when on the surface, is run with the oil fuel, but as soon as it becomes necessary to dive this fire is extinguished, the after-hatch is opened by unlocking the door of the bulkhead separating the after from the bulkheaded end of the vessel, and by a system of fans the hot air from the fire-room is driven outboard. Then the after telescopic hatch is reefed and secured, the soda is thrown from the receptacle where it has been heated into the jacket of the caustic-soda boiler, the fires are put out, the smoke-stack is taken in and securely fastened, and the machinist, leaving the engine-room, goes through the bulkhead door into the forward compartment, where he has complete control of the machinery and boiler by means of a duplicate set of gauges and levers. In case of an attack, the man detailed for operating the main torpedo is left in the after compartment, where he has access to that weapon and to the buoy, reel, and other mechanical appliances employed in its operation.

The helmsman, who controls the steering apparatus that governs the horizontal and perpendicular rudders, also operates with his feet the levers which are connected by links to the throttle that supplies steam to cylinders K K. These last function like the Westinghouse brake, and are connected with pistons to the cylinders J J. Through their agency water is at will admitted into or forced out of the larger receptacles, either from one end or from both ends simultaneously. The effect of discharging water is of course to increase the buoyancy of the vessel; and of admitting it, to decrease this quality so that without changing structural weights the boat is enabled to rise or sink perpendicularly, or, by admitting more water in one end than in the other, to take a downward or an upward course. Though this does away with the necessity of the horizontal rudder, it is kept as an additional resource for steering. In case of accident to the connecting pipes or machinery the vessel is supplied with water receptacles and hand-pumps, which are able to govern its submergence so that should all other mechanism break down the boat is so completely under the control of the operator that it can at all times be brought to the surface. As an additional safeguard, there is on the outside of the boat a quantity of ballast which can be readily detached by the arms or sleeves previously described, and so effectively that the reserve buoyancy thus gained will alone carry the boat to the surface.

In addition to the main torpedo and buoy resting in the cylindrical apertures aft, other torpedoes, connected by spans, are carried on deck. The method of their employment in attack is to go under the body of the vessel athwartship, and to liberate them. As they are fitted with magnets, they will, it is claimed, when freed, attach themselves to the bilges of the enemy's vessel, while the *Peacemaker* can continue her cruise and let them act automatically, or, backing off to a distance greater than the depth of water in which she then is, safely explode them by conventional electrical appliances. With the increased speed of the present boat there are various methods of attacking vessels of war when under way, among them one which is somewhat similar to that described above.

The *Peacemaker*, when under the body of the vessel athwartship, would liberate a buoy, B, that is connected with a torpedo, T, by a chain, the length of which depends upon the depth beneath the buoy the torpedo is desired to float. The steel tow-line to the torpedo is payed out from reel G to a sufficient length, and then by going ahead with the boat the torpedo is drawn close under the opposite side of vessel from buoy B. In this position the torpedo can be exploded by electricity.

If necessary, by liberating buoy B, while crossing the bow on the starboard side of the fore-foot of a vessel, the forward motion will draw the torpedo, T, close in to the opposite side; then, by a system of push-pins on the torpedo, the operator learns that it is in close contact and ready for explosion by electricity. Should the enemy's vessel be at anchor the tide can be employed for the purpose of bringing the buoy on one side of the vessel while the torpedo is on the other.

The boat is supplied with the ordinary incandescent lights, or apparatus for lighting the interior for night attacks.

TORPEDOES.

America has contributed to modern warfare many of its most valuable inventions. In the decade of 1850–60 the steam frigates of the *Merrimac* class revolutionized the naval constructions of the world, and became the models for the war-ships of the great maritime powers. In the same period our coast defences reached the high-water mark of modern development, and, soon to be crystallized, there were seething in the brains of American inventors ideas of guns, ships, and projectiles which made history. Though to-day our created contributions to quick peace through arrested or irresistible war are meagre, still many of the theories which make possible modern ordnance and ships are the fruits of American genius and industry.

Is the future to be as fertile in thought and deed? Are the destroyers of Ericsson, the dynamite safety shells of Hayes, the guns of Zalinski, the torpedoes of Howell, Sims, or Berdan, the turrets of Timby, the submarine monitors of Tuck, the gun-carriages of King or Buffington, the ordnance of Sicard, Benét—are these to prove that Yankee brain and brawn are potent yet for the mastery of the problem?

The country has no plainer duty than to foster by every care American ideas working in national ways of thought. It is rich, public sentiment is ripe and responsive, and Congress should encourage in peace the experiments which may make war impossible. In the question of ship armament and sea-coast fortifications notably, the value of torpedoes is now so generally recognized that the definite selection of some type has attained an importance which demands most careful consideration. All experts agree that they are vital, but there is not that consensus of opinion which within limits affirms exactly what should be done.

The Fortification Board in their report say: "It is not generally considered possible to bar the progress of an armored fleet by the mere fire of a battery; some obstructions sufficient to arrest the ships within effective range of the guns is necessary. The kind of obstruction now relied upon is the torpedo, in the form of a submarine mine, and, except in special cases, exploded by electric currents which are so managed that the operator on shore can either ignite the mine under the ship's bottom, or allow the ship to explode it by contact. In deep channels the submarine mines are buoyant; in comparatively shallow waters they are placed upon the bottom—the object in both cases being to touch or nearly approach the hull of the vessel. Submarine mines are not accessaries to defence, but are essential features wherever they can be applied."

The Senate Committee on Ordnance and War-ships reported: "Concerning another class of torpedoes, 'fixed' or 'anchored' or 'planted,' technically known as submarine mines, there is a great popular misapprehension. Their value is greatly over-estimated. They require picked and trained men for their management, electrical apparatus for their discharge and for lighting up the approaches, stations on shore secure against sudden assault, a flanking fire of canister and case shot and of machine guns (themselves protected), light draught picket-boats, and the overshadowing protection of armored forts and heavy guns. None of these things can be extemporized. The submarine mine alone is of little use, and it must accompany, not precede, more costly and less easily prepared means of defence."

There is, however, a more definite agreement as to the value of torpedo-boats. The Fortification Board declare: "Among the most important means of conducting an active defence of the coast is the torpedo-boat, which, although recently developed, has received the sanction of the nations of Europe, each one of which now possesses a large number of these vessels. Their use will be quite general. First, in disturbing blockades, and preventing these from being made close, as no fleet would like to lie overnight within striking distance of a station of these boats; secondly, in attacking an enemy's ship enveloped in fog or smoke; thirdly, in relieving a vessel pursued by the enemy; and fourthly, in defending the mines by night and by day against attempts at countermining, and in many other ways not necessary to recapitulate." Impressed with the utility of this mode of defence, the Board recommended the construction of one hundred and fifty of these boats, and the organization of a special corps of officers and men from the navy trained to their use.

In England, Commander Gallwey does not hesitate to say that the torpedo-boat is for harbor defence so superior to the submarine mine that he would not be surprised if before long it superseded the latter altogether. In France, Charmes insists that an armored vessel will run the most serious risk if a torpedo-boat is allowed to approach unobserved to within one thousand to fifteen hundred feet; that the torpedo will surely triumph over the iron-clad, and that armor has been vanquished, not by the gun, but by the torpedo.

A NAVAL RESERVE.

Among the problems to be solved by an efficient naval administration there is none more difficult or of greater importance than the formation of reserves of seamen. Our late war exposed the nation's weakness in sailors. At the beginning of hostilities the fleet, on paper, consisted of forty-two ships of all classes, mainly sailing-vessels, with a few paddle-wheel steamers, and less than ten screw-vessels with auxiliary power. Its *personnel* comprised seven thousand of all grades. And yet, to blockade a coast of over three thousand miles in length, the Secretary of the Navy had at his disposal but three effective vessels, and a reserve of only two hundred seamen on all the receiving-ships and at all the naval stations.

As late as the first of July, 1863, there were not men enough to carry out efficiently the work imposed upon the navy, and of the thirty-four thousand blue-jackets twenty-five thousand were landsmen. Secretary Welles, at the end of the same year, complained that there were no reserve seamen, that the supply for immediate and imperative duties was so inadequate that one of the largest and fastest steamers destined for important foreign service had been detained for months in consequence of the need of a crew, and that many other vessels were very much short of their complements. The cause of this was want of foresight, of prudence, of national common-sense even. We did not lack the material from which crews could have been drawn, for in 1860 over seventy-five thousand men sailed in the American merchant marine, fifty thousand of whom, under any system of enrolment suited to our national instincts and prejudices, would, before the end of 1861, have been available for duty on shipboard.

In peace there had been no organization, so when war came we were almost helpless, and as late as the end of 1863 not twenty per cent. of the men who should have been ready for service were in government ships. Let *doctrinaires* theorize as they may, this was not the fault of our maritime class, for thousands of sailors and fishermen who had already entered the army were by force of law denied the opportunity either of enlisting in, or of being transferred to, the navy. In addition, the operation of the draft was made detrimental to the naval interests of the country, for it violated the Act of May, 1792, which exempts from military duty all mariners actually employed in the sea service of any citizen or merchant within the United States. Furthermore, the government unjustly discriminated against the seaboard towns, for not only was the seafaring class, which is fostered and cherished by all maritime governments, withdrawn from the element to which it has been accustomed, but in addition sailors actually afloat were taken from their ships and compelled, under the penalty of law, to enter the land service. It was not until 1864 that Congress finally enacted the law which enabled seamen serving as soldiers to be drafted into the navy.

How different would have been the state of affairs had there existed in 1861 some system of government administration as to the creation of naval reserves, or, more far-reaching still, had we been free from that illogical distrust which possessed the whole country! The fear of too much centralization was the stock in trade of professional patriots, and the people, hampered by traditions which had come down to us from our English ancestors, saw in any attempt towards efficient war preparation in times of peace all the dangers they had been taught to believe existed in standing armies.

England acted more wisely, for she had been taught a grim lesson by her adversities, and without fear we might have profited by her example. In the history of the Peninsula war, Napier, after picturing the horrors of the fearful April night when Badajoz was stormed, asked, bitterly,

"And why was all this striving in blood against insurmountable difficulties? Why were men sent thus to slaughter when the application of a just science would have rendered the operations comparatively easy?

"Because the English ministers, so ready to plunge into war, were quite ignorant of its exercises; because the English people are warlike without being military, and, under the pretence of maintaining liberty which they do not possess, oppose in peace all useful martial establishments. In the beginning of each war England had to seek in blood for the knowledge necessary to insure success."

Equally has this always been the attitude of the American people towards every attempt made in peace to prepare for war. Besides this national distrust, prejudices had to be overcome which have existed both in the navy and the merchant marine. Our naval officers have never made any determined effort to create a reserve, either because they have not fully grasped the correlation and interdependence of the navy and the merchant marine, or because they have doubted the wisdom of spending upon an outside issue appropriations which, given to the navy, would produce a more immediate and tangible result. But from both points of view they are wrong, "for a navy unsupported by a merchant marine is a hot-house plant which may produce great results for a while, but cannot endure the strain of a long protracted campaign." From the merchant marine the *personnel* of the navy in war must come, and it is a fallacy to believe that by a small addition to our ordinary naval resources we would be able to cope with the navies of other maritime powers, or that in a long war an efficient and numerous reserve is not of greater importance than a few more seamen permanently maintained in the navy during peace.

To the merchants and ship-owners the question is one of vital importance. The earliest and most disastrous consequence of war will fall upon the shipping interest. Under any system of defence the necessities of the navy must withdraw seamen from the merchant service and raise the rate of wages. If, then, by timely precautions during peace, we can diminish the probability that war can occur at all; if we are ready upon the outbreak of war to show that our homeward-bound ships are safe; if we can abolish or modify the risk that the employment of seamen would be abruptly suspended by embargo or interfered with by impressment or draft; if we can attach the sailor to his country, and prevent him from seeking employment under other flags, surely the owners of our ships and merchants will reap the greatest advantage. Abroad the importance of the subject has been fully recognized. France, under a system which has existed for over two hundred and fifty years, maintains a reserve of 172,000 men, who are between the ages of eighteen and fifty; 65,000 of these are between the ages of twenty and twenty-six, 15,000 are usually kept afloat, and 6000 more are quartered on shore. Germany has 15,000, and England nearly the same number.

Notwithstanding the decadence of our shipping interest we have a large force from which to draw. The maritime population of this country numbers over 350,000, of whom 180,000 are available for the fleet. This number of course includes all those in any way connected with sea industries, and embraces coasters, fishermen, whalers, yachtsmen, boatmen, and all workmen in ship-building yards and equipment shops and stores.

To man our ships in time of war three means are open: voluntary enlistment, draft or impressment, or employment of men enrolled in a naval reserve. It would be unreasonable to depend altogether upon the loyal and unselfish patriotism of necessitous men serving before the mast, and there is a chance that mere enthusiasm would not induce a seaman to join the navy if employment was being offered elsewhere at increasing rates of pay. Impressment under any name is unpopular. In its common form it is illegal, and the draft is ever a last resort and always a dangerous measure. Nothing, then, remains as a certainty but to turn towards the naval reserve as the best means of manning our fleet. In time of war not only would the men enrolled come forward willingly and be immediately available, but deserters would have the machinery of the law put in motion for their apprehension, and popular feeling would be as earnest in support of their arrest as it would be opposed to all attempts which enforced the arbitrary powers of draft or impressment.

No system exists abroad entirely suited to our necessities and our national instincts; but, generally speaking, that adopted in England comes nearest to what we should employ. Naturally our lake sailors, coasters, fishermen, and yachtsmen would form the main body of the reserve. These should be enrolled, divided into classes, be given each year a certain fixed sum of pay, with an increase for each day's drill, and at stated times they should be embarked for great gun practice at sea, so they might learn something of man-of-war routine and discipline. The officers could be drawn from the merchant marine, from the graduates of the school-ships, and from former officers of the regular and volunteer services who are now in civil life.

FORCED DRAFT.

The subject of forced draft is of great importance, and, as a corollary of high-speed development, is being studied with keen interest. There are wide differences of opinion not only as to the proper systems, but even as to the value of the principle. The literature as yet is rather meagre, but an excellent compilation of existing material will be found in the latest publication of the Naval Intelligence Office.

"A forced draft in the furnaces," explains the *Marine Engineer* of September, 1887, "can be generated in two ways: first, by exhausting the uptakes and funnels of the products of combustion, when a greater flow of air will necessarily take place through the fire-bars; and secondly, by increasing the pressure of the air in the furnaces beyond that of the atmosphere. The steam-blast in marine boilers is well known to engineers as a means of quickly getting up the steam after its pressure has dropped ; but the locomotives on our railways afford a very good illustration of how boilers may be continuously worked under forced combustion through a jet of steam exhausting the smoke-box and funnel of the products of combustion. This system of creating a draft involves a very large expenditure of steam and water, and as it is a *sine qua non* in these days of high pressure that only fresh water should be used in boilers, and also as only a limited supply of this element can be carried in a ship, it follows that the plan of inducing a forced draft by means of a steam jet in the funnel cannot be well adopted in marine boilers.

"Mr. Martin, the inventor of the well-known furnace doors, substitutes a fan in the uptake for the steam jet, and so arranges his funnel that in the event of the forced draft not being required the gases of combustion arising from natural draft will not be impeded in their exit to the atmosphere. He claims for his invention that it does away with all necessity for closing in the stoke-holds or furnaces, and that in war-ships funnels could be dispensed with, as the gases and smoke could be discharged anywhere from the fans. He also claims that by his plan of producing a draft the boiler-tubes become much more efficient as heating surfaces, and that the ends of the tubes in the fire-box are not so liable to be burned away, and that therefore there will be less chance of the boiler leaking round the tubes. There appears to be some grounds for these latter assumptions, for it is a well-known fact that the tubes of locomotive boilers, which are worked, as we have seen, on the exhaust principle, do very much more work than those of marine boilers before they are ferruled or rolled. It can also be shown by a very simple experiment that when the gases are sucked or drawn through the tubes the flame extends a much greater distance along the tube than when the gases are driven through the tubes. In this latter case the flame impinges on the tube-plates before separating into tongues and entering the tubes; but when sucked through the tongues of flame commence at some little distance from the plate before penetrating the tubes, and the ends are not therefore burned as when the flame impinges directly on them. It may be urged, however, against Martin's system that owing to the greatly increased volume of the products of combustion due to their temperature, fans of from three to four times the size of those used in other systems are required; also, that the uptakes have to be made larger and heavier to take in the fans; and lastly, that the fans themselves are likely to be quickly rendered inefficient through working in a temperature of at least a thousand degrees. These objections prove so formidable that up till the present time Martin's plan of creating a forced draft has made little or no headway.

"The other plan for creating an artificial draft in marine furnaces is to force air into them by means of fans. This is done either by closing in the whole of the stoke-hold and filling it with air of a pressure greater than that of the atmosphere, or by pumping the air direct into the furnace. This latter is the usual practice in the mercantile marine, where economy of fuel is sought after. Mr. Howden seeks, by first heating the air, and then forcing it by means of fans into the furnaces and ash-pits, to insure a very rapid and complete combustion of the coal. His plan has been carried out in the Atlantic liner *Ohio* quite recently, and the results as published lead one to expect that with a little more progress in the direction in which he is working our ships will be driven across the Atlantic without the expenditure of any fuel whatever. The fact of heating the air to a temperature of two hundred degrees before it enters the furnace cannot go very far in affecting either the rapidity or the completeness of the combustion of the fuel, and it certainly cannot affect the economy. Where the fire-grate area is small compared with the total heating surface, good evaporative results are likely to be obtained; and in the *Ohio* the fire-grate area was certainly smaller than is usual for the same sized boilers fitted with forced draft. The trip of the *Ohio* to America has given somewhat different results to those of the official trials, and it is a question whether any saving in weight, either in the apparatus required to produce forced draft under this system, or in the economy of fuel to be derived from it, has been obtained more than exists in the system of closed stoke-holds.

"The only plan that seems to hold its own is the closed stoke-hold system, and the results that have been obtained with it in the navy are so satisfactory that Messrs. J. & G. Thomson are about to adopt it in the two large Inman liners they are now building; and also several other firms are about to introduce it in preference to all other plans for increasing the efficiency of their boilers and promoting greater economy. In the Royal Navy space and weight are of such vital importance that the boilers have to be constructed on principles the very reverse of those which exist in boilers specially designed for high evaporative work per pound of fuel; and it is not, therefore, to be wondered at that the consumption of fuel per indicated horse-power has not been reduced since the introduction of forced draft; but, on the other hand, the capabilities of the boilers have been expanded far beyond the expectations of a few years ago. In the mercantile marine there is no reason whatever why the system of closed stoke-holds for creating a forced draft should not combine economy with greater efficiency in the boilers."

These conclusions are not universally accepted, as will be seen in the following extract from the article contributed by Assistant Engineer R. S. Griffin, United States Navy, to the Naval Intelligence Office publication mentioned at the beginning of this subject.

"The forced-draft trials of the *Archer* class," he writes, "go far towards sustaining the objections raised by Mr. Howden against the closed stoke-hold system. The trials of the *Archer*, *Brisk*, and *Cossack* had to be discontinued on several occasions, owing to leakage of the boiler-tubes; and when it is remembered that these trials are for only four hours, and that no provision is made for hoisting ashes, it becomes a question of serious consideration whether the maintenance of this high power for such a short period brings with it advantages at all comparable with the continued development of a reasonably high power with an economical expenditure of coal, such as is possible with the closed ash-pit system.

"A number of steamers have been fitted with Howden's system during the past year, among others the *Celtic*, of the White Star Line, and the *Ohio*, of the International Navigation Company. One of the latest steamers fitted with this system is the *City of Venice*, whose engines were converted from compound to quadruple expansion. Her boilers were designed to develop 1800 indicated horse-power with eighty square feet of grate, but on trial she could only work off 1300 indicated horse-power, owing to some derangement of the valves. She was afterwards tried with half the grate surface in use, when it was demonstrated that there would be no difficulty in developing the power so far as the boilers were concerned. Unfortunately, no data as to weight of boilers, space, or heating surface are obtainable.

"In 1886 the *Alliance* was supplied with new boilers, fitted with a system of forced draft designed by the Bureau of Steam Engineering. It was originally the intention of the Department to put six boilers in this vessel, as in the *Enterprise* and *Nipsic*, but with the introduction of the forced-draft system, which was purely experimental, this number was reduced to four, having a total grate surface of 128 square feet. The boilers were designed to burn anthracite coal with natural draft, and were of course unsuited to the requirements of forced draft, the ratio of heating to grate surface being only 25.6 to 1, and the water surface and steam space being small. The maximum indicated horse-power developed on trial was 1022, but any attempt to run at this or at increased power for any length of time was attended with so much priming of the boilers that the trial had to be discontinued. Alterations were made in the boilers to prevent the priming, but no continuous trial was had previously to the sailing of the *Alliance*. The results obtained on a measured base were, however, sufficient to demonstrate the practicability of the system, and to show that a higher power could be maintained with the four boilers at forced draft than with the original eight boilers at natural draft.

"The practical working of the system at sea presents no difficulty, as a recent run of the *Alliance* has demonstrated. On a continuous run of ten hours, using only two boilers with sixty square feet of grate (the grate surface of each boiler having been reduced to thirty), the mean indicated horse-power was 668 and the maximum 744, being respectively 11.1 and 12.4 indicated horse-power per square foot of grate. There was an entire absence of priming, and no difficulty was experienced in operating the forced-draft apparatus, the length of the trial having been determined by the arrival of the vessel in port. The coal burned was Welsh, of fair quality, the consumption being 29.9 pounds per square foot of grate.

"The efficiency of the system may be judged by the results obtained from an experimental boiler at the Washington Navy-yard. The boiler was of the marine locomotive type, and had a ratio of heating to grate surface of 32.73 to 1, with a water space of 245 and a steam space of 163 cubic feet. The coal burned was ordinary Cumberland Valley bituminous, and the evaporation, when burning as much as forty pounds per square foot of grate, was 6.61, while with 37.5 it was 7.24, and this with a moderate air pressure—1.5 inches in ash-pit and one inch on furnace door."

It is unfair to attempt the explanation of this system without accompanying drawings, but it may be stated that the air, drawn by fan-blowers from the heated portion of the fire-room, is forced through a passage into the ash-pit and furnace, a portion of the current being directed by an interposed plate through the holes in the furnace frame. By the agency of a double row of holes the greater portion of the air which enters the furnace passes around the frame, thence through other apertures to the space between the furnace door and lining, and finally to the furnace through the space between the lining and furnace frame. The supply of air when firing or hauling ashes is shut off by a damper.

APPENDIX II.*

THE QUESTION OF TYPES.

The following letter appeared in the *Times* (London) of April 4, 1885:

"SIR,—May I request the favor of space in the *Times* in which to comment upon the opinions recently expressed by Sir Edward Reed and other writers respecting the designs of the *Admiral* class of ships in the Royal Navy, and the four central-citadel ships which were laid down subsequently to the *Inflexible?*

"Having been closely associated with Mr. Barnaby in the designing of all these ships, with the exception of the *Ajax* and *Agamemnon,* I can speak with full knowledge of both the history and intentions of the designs.

"Moreover, my share of the responsibility for the professional work involved in those designs remains, although my official connection with the constructive department of the Admiralty was severed years ago. It need hardly be added that the remarks which follow simply embody my own opinions, and that I write neither as an apologist for Mr. Barnaby nor as a champion of the ship-building policy of the Admiralty.

"The sweeping condemnation which has been pronounced against the most recent English battle-ships is based upon the consideration of one feature only in their fighting efficiency, *viz.*, the extent of the armor protection of their sides in the region of the water-line. There has been no discussion in the letters to which I have referred of the comparative speeds, armaments, or other qualities of the French and English ships. But the fact that the French ships are armor-belted from end to end, while the English ships have no vertical armor on considerable portions of the length at the region of the water-line, is considered by Sir Edward Reed so serious a matter that he says, 'The French armored ships must in all reason be expected to dispose of these English ships in a very few minutes by simply destroying their unarmored parts.'

"From this opinion I most strongly dissent, for reasons which are stated below; and I venture to assert that if attention is directed simply to the possible effects of gun-fire, while the possibly greater risks incidental to attacks with the ram and torpedo are altogether neglected, then there is ample justification for the belief that the English ships of recent design can do battle on at least equal terms with their contemporaries in the French or any other navy.

"In all recent armored ships, if the wholesale and extremely rapid destruction of the unarmored portions of the ships which Sir Edward Reed contemplates actually took place, very considerable risks would undoubtedly result; but in my judgment these risks are not sensibly affected by the different distribution of the armor on the ships of the two great navies. And, further, there is every reason for doubting whether such wholesale destruction of the unarmored parts could be effected with the appliances which are now available, not merely in 'a few minutes,' but in a very considerable time, and under the most favorable conditions for the attack. Nor must it be forgotten that armor, even of the greatest thickness, applied to the sides or decks of ships is not impenetrable to the attack of guns already afloat, while the *mitraille,* which is driven back into a ship when armor is penetrated, is probably as destructive as any kind of projectile can be, and attacks directly the vital parts which the armor is intended to protect.

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* From the General Information Series No. V., U. S. Naval Intelligence Office.

"In support of these assertions I must ask permission to introduce certain detailed statements which appear to be absolutely necessary to a discussion of the subject, but which shall be made as brief and untechnical as possible.

"It appears that the points raised by the discussion may be grouped under two heads. First, does the shortening of the belt in the English ships introduce such serious dangers if they have to do battle with the French ships? Secondly, what should be considered the principal uses of armor-plating in modern war ships? The second question may be considered to include the first; but it will be convenient to take the questions in the order in which they have been placed, as, after all, the greatest immediate interest centres in the comparison between existing ships.

"At the outset it is important to remark that in the most recent designs of armored ships for all navies, increase in speed, armament, and thickness of armor has been associated with a decrease in the area of the broadside protected by armor. Further, it has been considered important in most cases to distribute the armored positions of the heavy guns in the ships in order to reduce the risks of complete disablement of the principal armament by one or two lucky shots which may happen when the heavy guns are concentrated in a single citadel or battery. This distribution of the heavy guns also gives greater efficiency to the auxiliary armament of lighter guns, and enables these heavy guns to be placed at a considerably greater height above water than was usual in former days, so that the chances of the guns being prevented from being fought in heavy weather are diminished, and their power as compared with the lower guns in earlier ships is increased, especially when firing with depression.

"The days of the 'completely protected iron-clad,' with the broadside armored throughout the length from the upper deck down to five or six feet below the water-line, have long gone by. The 'central battery and belt' system has also been practically dropped, whether the battery contained broadside guns or formed a citadel protecting the bases of the turrets. In short, on modern battle-ships there now remains only a narrow belt of armor, rising from five or six feet below the load-line to two or three feet above it. This narrow strip of armor in the French ships extends from end to end, and is associated with a protective deck worked at the height of the top of the belt, and forming a strong roof to the hold spaces beneath. In the English ships of the *Admiral* class the belt of armor extends somewhat less than half the total length, protecting one hundred and forty to one hundred and fifty feet of the central portion of the ship (in which are situate the engines and boilers), and protecting also the communications from the barbette towers to the magazines. At the extremities of the belt strong armored bulkheads are built across the ships. The protected deck is fitted at the upper edge of the belt over the central portion. Before and abaft the bulkheads, where there is no side armor, the protection consists of a strong steel deck, situated from four to five feet below water, and extending to the bow and stern respectively. Upon this under-water deck are placed coal-bunkers, chain-lockers, fresh-water tanks, store-rooms, etc., the spaces between it and the deck next above being subdivided into a large number of water-tight compartments or cells by means of longitudinal and transverse bulkheads. A water-tight top or roof to these compartments is formed by plating over the main deck-beams with thin steel at the same height above water as the top of the armor-belt. In this manner the unarmored ends above the protective deck are not merely packed to a large extent with water-excluding substances when the vessel is fully laden, but they are minutely subdivided into separate compartments, which can only be thrown into communication with one another by means of very extensive injuries to the partitions.

"In all the modern French ships, as well as in the *Admiral* class, a light steel superstructure of considerable height is built above the level of the belt-deck; the living quarters of the crew and the stations of the auxiliary armament are contained within this light erection, which also surrounds the armored communications from the barbette towers to the magazines. In this manner a ship with a small height of armored freeboard is converted into a high-sided ship for all purposes of ordinary navigation, sea-worthiness, and habitability; while spaces are provided in which a more or less considerable number of light guns can be fought concurrently with the heavy guns placed in the armor-protected stations. The radical difference, therefore, between the French ships and the *Admiral* class, independently of other considerations than the armor protection of the water-line, consists in the omission of the side armor at the extremities, and the use instead of the side armor of the strong under-water deck with cellular subdivision and other arrangements for adding to the protection and securing the buoyancy of the spaces at the ends, into which water may find access through the thin sides if they are shot through and seriously damaged in action. If the completely belted French ship has to fight a vessel of the *Admiral* class, the latter has obviously the greater chance of damage to the narrow strips of the sides lying above the under-water deck before and abaft the ends of the belt. If the action takes place in smooth water, when the ships are neither rolling nor pitching, but are simply in motion, the chances of hitting these narrow strips in the water-line region might not be very great; but it must be admitted that even the lightest guns would penetrate the thin sides of the English ships and admit more or less considerable quantities of water into the ends. If, on the other hand, the fight takes place in a sea-way, with the ships rolling and pitching, then the relative importance of penetration of these narrow strips of the ends of the English ships becomes much less, because the belt armor of the French ships will be brought out of water for a considerable length of the bow and the stern by a very moderate angle of pitching, or by the passage of a comparatively low wave, and because rolling motion of the ships will alternately immerse or emerge the belt armor, even at the midships part, where it has its greatest thickness. In fact, as I have more than once said publicly, it is clearly an error to limit criticism to the longitudinal extent of the belt armor in modern ships, and to exclude consideration of the vertical extent of the armor above and below the load-line. Apart from any discussion of the question from the artillerist's point of view, or any attempt to determine the probability or otherwise of the wholesale destruction of the unarmored portions of modern battle-ships by shell-fire from large guns, or by the projectiles from rapid-firing and machine guns, it is perfectly obvious to any one who will examine into the matter that the risk of damage to the light superstructures situated above the belt must be greater than the corresponding risk of damage to the narrow strips of side area exposed at the unarmored ends of the *Admiral* class, between the level of the belt-deck and the water-line.

"Sir Spencer Robinson, after his inspection of the models shown him at the Admiralty, recognizes the fact that in the French belted ships (of which the *Amiral Duperré* is an example), if the light sides above the belt-deck are destroyed or very seriously riddled in action, the ship would be capsized in a very moderate sea-way. He further emphasizes the statement that the ships of the *Admiral* class in the English navy, if similarly treated, would also capsize under the same conditions, and he appears to be surprised at the admission having been made. The fact is that there has never been any assertion that the *Admiral* class would be safe against capsizing independently of assistance given to the armor-belted portions by the unarmored structure situated above. On the contrary, from the first, in the design of these ships, it was recognized that their stability, in the sense of their power to resist being capsized, if inclined to even moderate angles of inclination, was not guaranteed by the armor-belts. In this respect they were in identically the same position as all other armored ships with shallow water-line belts and isolated armored batteries placed high above water.

"What has been said respecting the *Admiral* class is this: If the unarmored ends above the protective deck were completely thrown open to the sea, then the initial stability (that is to say, the stiffness of the ships or their power to resist small inclinations from the upright) would still be guaranteed by the central armored portions. So fully did we appreciate the fact that the life of the ship in action (as determined by her power to resist large inclinations) depends greatly upon the assistance given by the unarmored superstructures to the armor-belted parts, that we were careful to make the structural arrangements of the superstructures above the belts such that they could bear a very considerable amount of riddling and damage from shot and shell without ceasing to contribute in the most important degree to the buoyancy and stability.

"There are double cellular sides between the belt and upper decks; the main bulkheads are carried up high above water; hatches and openings are trunked up and protected by coffer-dams. In short, every possible precaution is taken to subdivide into compartments, and thus limit the spaces to which water can find access when the outer sides are penetrated or shattered, as well as to facilitate the work of stopping temporarily shot-holes in the sides.

"Now, without in the least intending to discredit the work of the French designers, I have to state that no corresponding or equal precautions have been taken in the portions of their ships lying above the belt-decks. And the absence of these features in the French ships is a great relative advantage to the English ships. Of course there is nothing to hinder the French from imitating our practice, but they are content to take the risks involved in a simpler construction, and in so doing they show their practical disbelief in the doctrine of armor-protected stability. I am aware that some eminent authorities do not concur with this view, and maintain that stability and buoyancy should be guaranteed by armor. To this point I will revert hereafter, but for the present I am content to say that, as between the French ships and the *Admiral* class, the most serious risks of damage by gun-fire in action are of the same kind, and, practically, are not affected by the shortening of the armor-belts in the English ships.

"Next I would refer to the differences which are undoubtedly involved in shortening the belts of the English ships. In the first place, by dispensing with the side armor towards the extremities a very considerable saving is effected in the weight and the cost of the armor fitted to the ships. Mr. Barnaby has recently given an illustration of this, where a ship, in other respects unchanged, has to be increased from 10,000 to 11,000 tons in displacement in order to carry the shallow armor-belt to the ends. In the *Collingwood* herself quite as large a proportionate increase of size would be involved in having a thick armor-belt from stem to stern. This saving in weight and cost of armor might, of course, be purchased too dearly, if dispensing with the armor involved possibly fatal risks to the ship. However the result may be attained, there is universal agreement that a ship-of-war should have her buoyancy, stability, and trim guaranteed as far as possible against the effects of damage in action. Now, in the *Admiral* class this matter was very carefully investigated before the design was approved. In order to prevent derangement of the trim of the vessels by penetration of the light sides above the protective deck at one end, arrangements were made in the design by means of which water can be introduced into the spaces occupied by coal-bunkers, etc., before the ships go into action.

"The extent to which water may be introduced is a matter over which the captain would necessarily have control. But even if the whole of the unoccupied spaces were filled with water, the increase in draught would not exceed fourteen to eighteen inches, and the loss in speed would not exceed half a knot. If only the coal-bunkers were flooded as a preliminary to action, the chance of any serious disturbance of trim, and consequent loss of manœuvring power or speed by damage to the light sides above the protective deck and near the water, would be very small, and the 'sinkage' of the vessel would be decreased considerably. But taking the extreme case, with the ends completely filled and a sinkage of fourteen to eighteen inches, a ship of the *Admiral* class would go into action with practically her full speed available, and with her ends so protected by under-water deck and the water admitted above that deck that damage to the thin sides by shot or shell penetrating at or near the water-line would not produce changes of trim or alterations of draught to any greater extent than would be produced if the armor-belt had been carried to the stem and stern. Nor would the admission of water into the ends render the vessel unstable.

"It has been urged that the sinkage due to filling the tank ends with water is a disadvantage, because it brings the upper edge of the belt armor in the *Admiral* class about fourteen to eighteen inches nearer the water than the upper edge of the belts of the French ships. If the greatest danger of the ships was to be measured by the smallness of their 'reserve' of 'armor-protected buoyancy' (that is to say, by the buoyancy of the part of the ship lying above her fighting water-line and below the belt-deck), then the *Admiral* class would not compare favorably with the fully belted French ships. But I have already explained that this is not the true measure of the greatest danger arising from the effects of gun-fire, and that it would be a mistake to assume that in either the French or the English ships the armor-belted portions of the vessels guarantee their safety when damaged in action.

"As between the *Admiral* class and the central-citadel ships of the *Inflexible* type there is a difference in this respect which has been much commented upon. When the ends of the citadel ships are filled with water, the armored wall of the citadel still remains several feet above water; whereas, in the *Admiral* class, the top of the belt under similar conditions is very near the water-level. All that need be said on this point is that, notwithstanding the greater height of the armored wall above water, the citadel ships have practically no greater guarantee of safety against capsizing by means of armor-protected stability than the *Admiral* class. In both classes the armored portions require the assistance of the unarmored to secure such a range and amount of stability as shall effectually guarantee their security when damaged in action. And, as has been stated above, this condition is true of all armor-clads with narrow armor-belts.

"One other objection to the shortened belts yet remains to be considered.

"It is urged that when the thin ends are broken through or damaged by shot or shell, jagged or protruding holes will be formed in the plating near the water-line, and then if the ships are driven at speed, the water will flow into the holes in large quantities, and produce serious changes of trim and loss of speed. In support of this contention, reference is made to the published reports of experiments made with the *Inflexible's* model about eight years ago. It is impossible to discuss the matter fully, and I must therefore content myself with a statement of my opinion, formed after a careful personal observation of these model experiments. First, it cannot be shown from the experiments that the presence of a shallow belt of armor reaching two to three feet above the still-water line would make any sensible difference in the dangers arising from the circumstances described. Holes in the thin sides above this belt would admit water in large quantities on the belt-deck when the vessel was under way, and if it could flow along that deck changes of trim and other disagreeable consequences would result. Secondly, it is certain that the numerous bulkheads and partitions, coffer-dams, etc., built above the belt-deck level in the *Admiral* class for the very purpose of limiting the flow of entering water would greatly decrease any tendency to check the speed or change the trim. Whether the belt be short or long, it is evident that gaping holes low down in the light sides will make it prudent for a captain to slow down somewhat if he wishes to keep the water out as much as possible. But between such prudence and the danger of disaster there is a wide gulf.

"Summing up the foregoing statements, I desire to record my opinion, based upon complete personal knowledge of every detail in the calculations and designs for the *Admiral* class, that the disposition of the belt-armor (in association with the protective decks and cellular sides, water-tight subdivision, etc., existing in the unarmored portions of the vessels situated above the protective decks) is such that the buoyancy, stability, trim, speed, and manœuvring capabilities are well guaranteed against extensive damage from shot and shell fire in action. And, further, that in these particulars the *Admiral* class are capable of meeting, at least on equal terms, their contemporary ships in the French navy.

"I must add that I am not here instituting any comparison between the 'fighting efficiencies' of the ships of the two fleets; nor have I space in this letter to do so. Opinions have differed, and will probably always differ, as to the relative importance of the different qualities which go to make up fighting efficiency. There is no simple formula admitting of general application which enables the comparative fighting values of warships to be appraised. As the conditions of naval warfare change and war material is developed, so the balance of qualities in ship designing has to be readjusted, and estimates of the fighting powers of existing ships have to be revised. And, further, different designers, working simultaneously, distribute the displacement, which is their sum total of capital to work upon, according to their own judgments of what is wisest and best for the particular conditions which the ships built from those designs have to fulfil. The designer who has the larger displacement to work upon has the better opportunity of producing a more powerful ship; but it by no means follows that he will secure so good a combination of qualities as a rival obtains on a smaller displacement. And hence I cannot but dissent from the doctrine that displacement tonnage is to be accepted as a fair measure of relative fighting efficiency, or that recent English ships are necessarily unable to fight recent French ships because they are of smaller displacement.

"In the preceding remarks I have been careful to confine myself chiefly to the naval architect's side of the subject, as it would clearly be out of place for me to say much respecting the artillerist's side. But, having had the great advantage of knowing the views of some of the most experienced gun-makers and gunnery officers, and having studied carefully what has been written on the subject, I would venture to say a few words.

"First, there seems, as was previously remarked, every reason for doubting, in the actual conditions of naval gunnery, whether it would be possible, not merely in a few minutes, but in a considerable time, to produce the wholesale destruction of the unarmored parts of modern war-ships which has been assumed in the condemnation of the *Admiral* class. If the *Collingwood*, or one of her successors, were simply treated as a moving target in a sea-way for the *Amiral Duperré* or one of her consorts, this would be a most improbable result. But, remembering that the *Collingwood* would herself be delivering heavy blows in return for those received, the chances of her disablement would necessarily be decreased. Secondly, it does not seem at all evident that the introduction of rapid-fire guns has such an important influence on the question of shortened belts as some writers have supposed. So far as machine guns are concerned, I well remember at the board meeting which decided to approve the building of the *Collingwood* the possible effects of machine-gun fire were discussed at some length, both in reference to the adoption of the barbette system and to the system of hull protection. The rapid-firing gun which has since been introduced is now a formidable weapon; but it may be questioned whether its effects upon the unarmored portions of modern war-ships would be so serious as those resulting from the shell-fire of heavier guns, and therefore it cannot with certainty be concluded that it would be advantageous to make arrangements for keeping out the projectiles from the rapid-firing guns now in use at the ends of the *Admiral* class. More especially is this true when it is considered that already rapid-fire guns of much larger calibre and greater power than the 6-pounder and 9-pounder are being made. To these guns three inches of steel would be practically no better defence than the existing thin sides, and the real defence lies in the strong protective deck. Shell-fire from heavier guns will probably be found the best form of attack against the unarmored or lightly armored portions of battle-ships, especially now that the use of steel shells with thin walls and large bursting charges is being so rapidly developed.

"I would again say that on this side of the subject I do not profess to speak with authority, and it is undoubted that great differences of opinion prevail; but it must not be forgotten that the Board of Admiralty, by its recent decision announced in the House of Commons, has reaffirmed the opinion that from the artillerist's point of view the existing disposition of the armor in the *Admiral* class is satisfactory. This has been done after the attention of the Board and the public has been most strongly directed to the supposed dangers incidental to the rapid destruction of the light superstructures lying above the under-water decks of the *Admiral* class. It would be folly to suppose that in such a matter any merely personal considerations would prevent the Board from authorizing a change which was proved to be necessary or advantageous. With respect to the possibility of making experiments which should determine the points at issue, I would only say that considerable difficulties must necessarily arise in endeavoring to represent the conditions of an actual fight; but in view of the diametrically opposite views which have been expressed as to the effect of gun-fire upon cellular structures, it would certainly be advantageous if some scheme of the kind could be arranged.

"There still remains to be considered the question of the uses of armor in future war-ships. This letter has already extended to too great a length to permit of any attempt at a full discussion. It will be admitted by all who are interested in the questions of naval design that an inquiry into the matter is urgently needed, even if it leads only to a temporary solution of the problem, in view of the present means of offence and defence.

"Armor, by which term I understand not merely vertical armor, but oblique or horizontal armor, is regarded in different ways by different authorities. For example, I understand Sir Edward Reed to maintain that side-armor should be fitted in the form of a water-line belt, extending over a very considerable portion of the length, and that such armor, in association with a strong protective deck, and armored erections for gun-stations, etc., should secure the buoyancy, trim, and stability of the vessel. At the other extreme we have the view expressed in the design of the grand Italian vessels of the *Italia* class. In them the hull-armor is only used for the purpose of assisting the cellular hull subdivisions in protecting buoyancy, stability, and trim, taking the form of a thick protective deck, which is wholly under water, and above which comes a minutely subdivided region, which Signor Brin and his colleagues consider sufficient defence against gun-fire.

"In these Italian vessels the only thick armor is used to protect the gun-stations, the pilot-tower, and the communications from those important parts to the magazines and spaces below the protective deck. The strong deck, besides forming a base of the cellular subdivision, is of course a defence to the vital parts of the ship lying below it.

"Between these two types of ships come the *Admiral* class of the English navy and the belted vessels of the French navy, whose resemblances and differences have been described above.

"In addition, there are not a few authorities who maintain that the development of the swift torpedo-cruiser, or the swift protected cruiser, makes the continued use of armor at least questionable, seeing that to attempt to protect ships by thick armor either on decks or sides, and to secure high speeds and heavy armaments, involves the construction of large and expensive vessels, which are necessarily exposed to enormous risks in action from forms of under-water attack, against which their armor is no defence. In view of such differences of opinion, and of the heated controversies which have arisen therefrom, the time seems certainly to have arrived when some competent body should be assembled by the Admiralty for the purpose of considering the designs of our war-ships, and enabling our constructors to proceed with greater assurance than they can at present. Questions affecting the efficiency of the Royal Navy clearly ought not to be decided except in the most calm and dispassionate manner. The work done by the Committee on Designs for Ships of War fourteen years ago was valuable, and has had important results. What is now wanted, I venture to think, is a still wider inquiry into the condition of the navy, and one of the branches of that inquiry which will require the most careful treatment is embraced in the question, 'What are the uses of armor in modern war-ships?'

"My own opinion, reached after very careful study of the subject, is that very serious limitations have to be accepted in the disposition and general efficiency of the armaments, if the principle of protecting the stability at considerable angles of inclination by means of thick armor is accepted, the size and cost of the ships being kept within reasonable limits. There is no difficulty, of course, apart from considerations of size and cost, in fulfilling the condition of armor-protected stability; but it may be doubted whether the results could prove satisfactory, especially when the risks from under-water attacks, as well as from gun-fire, are borne in mind, and the fact is recognized that even the thickest armor carried or contemplated is not proof against existing guns. No vessel can fight without running risks. It is by no means certain, however, that the greater risks to be faced are those arising from damage to the sides in the region of the water-line and consequent loss of stability. So far as I have been able to judge, it appears possible to produce a better fighting-machine for a given cost by abandoning the idea of protecting stability, buoyancy, and trim entirely by thick armor, and by the acceptance of the principle that unarmored but specially constructed superstructures shall be trusted as contributories to the flotation and stability. Thick vertical side-armor, even over a portion of the length, appears to be by no means a necessary condition to an effective guarantee of the life and manageability of a ship when damaged in action; and it seems extremely probable that in future the great distinction between battle-ships and protected ships will not be found in the nature of their hull protection in the region of the water-line, but in the use of thick armor over the stations of the heavy guns in battle-ships.

"The decisions as to future designs of our battle-ships is a momentous one. It can only be reached by the consideration of the relative advantages and disadvantages of alternative proposals. It cannot be dissociated from considerations of cost for a single ship.

"On all grounds, therefore, it is to be hoped that a full and impartial inquiry will be authorized without delay; for it may be assumed that, however opinions differ, there is the common desire to secure for the British navy the best types of ships and a sufficient number to insure our maritime supremacy. I am, sir, your obedient servant,

"W. H. WHITE.

"ELSWICK WORKS, *March 26th.*"

The following reply by Sir Edward Reed appeared in the *Times* of April 8, 1885, the omitted portions being personal allusions which have very little bearing upon the discussion, and which are of no interest to a professional reader outside of England:

"It is not Mr. White's fault but his misfortune that he is compelled to admit the perfect correctness of the main charge which I have brought against these six ships, *viz.*, that they have been so constructed, and have been so stripped of armor protection, that their armor, even when intact and untouched, is wholly insufficient to prevent them from capsizing in battle. Mr. White expends a good deal of labor in attempting to show that their unarmored parts would have a better chance of keeping the ships upright and afloat than I credit them with, which is a secondary, although an important, question; but he frankly admits that these six ships of the *Admiral* type are, and are admitted to be, so built that their 'stability in the sense of the power to resist being capsized if inclined to even moderate angles of inclination is not guaranteed by their armor-belts.'

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"I have no doubt it would suit the purposes of all those who are or who have been responsible for those ships if I were to allow myself to be drawn, in connection with this question, away from the essential points just adverted to into a controversy upon the efforts made by the Admiralty to give to these ships, which have been denied a reasonable amount of armor protection, such relief from the grave dangers thus incurred as thin sheet compartments, coffer-dams, coals, patent fuel, stores, etc., can afford. (Cork is what was at first relied upon in this connection, but we hear no more of it now.) But I do not intend to be drawn aside from my demand for properly armored ships of the first class by any references to these devices, and for a very simple reason, *viz.*, all such devices, whether their value be great or small, are in no sense special to armored ships; on the contrary they are common to all ships, and are more especially applied to ships which are unable to carry armor. The application of these devices to ships stripped of armor does not make them armored ships, any more than it makes a simple cruiser or other ordinary unarmored vessel an armored ship; and what I desire, and what I confidently rely upon the country demanding before long, is the construction of a few line-of-battle ships made reasonably safe by armor, in lieu of the present ships, which, while called armored ships, in reality depend upon their thin unarmored parts for their ability to keep upright and afloat. Besides, I do not believe in these devices for ships intended for close fighting. I even believe them likely, in not a few cases, to add to their danger rather than to their safety. If, for example, a raking shot or shell should let the sea into the compartments on one side of the ship, while those on the other side remain intact and buoyant, this very buoyancy upon the uninjured side of the ship would help to capsize her.

"Mr. White says that no vessel can fight without running risks, and thinks that thick, vertical side-armor, even over a portion of the ship's length, is not a necessary guarantee of the life of a ship. Well, sir, we are all at liberty to think, or not think, what we please, so far as our sense and judgment will allow us; but Mr. White, like all other depreciators of side-armor, fails utterly to show us what else there is which can be relied upon to keep shell out of a ship, or what can be done to prevent shell that burst inside a ship from spreading destruction all around. He refers us to no experiments to show that the thin plate divisions and coffer-dams, and like devices, will prove of any avail for the purpose proposed. In the absence of any such experiments, he tells us, as others have told us, that Signor Brin and colleagues in the Italian Admiralty consider 'a minutely subdivided region' at and below the water-line 'sufficient defence against gun-fire.' But I do not think Signor Brin believes anything of the kind; what he believes is that the Italian government cannot afford to build a fleet of properly armored line-of-battle ships for hard and close fighting, and that, looking at their limited resources, a few excessively fast ships, with armor here and there to protect particular parts, and with ample capabilities of retreat to a safe distance, will best serve their purpose. I do not say that he is wrong, and I certainly admire the skill which he has displayed in carrying out his well-defined object. But that object is totally different from ours, and our naval habits, our traditions, our national spirit, the very blood that flows in our veins, prevent such an object from ever becoming ours.

"Mr. White all through his letter, in common with some of his late colleagues at the Admiralty, thinks and speaks as if naval warfare were henceforth to be chiefly a matter of dodging, getting chance shots, and keeping out of the enemy's way; and this may be more or less true of contests between unarmored vessels. But why is not the line-of-battle ship *Collingwood* to be supposed to steam straight up to the enemy, I should like to know? and if she does, what is to prevent the enemy from pouring a raking fire through her bow, and ripping up at once, even with a single shell, every compartment between the stem and the transverse armored bulkhead?

"It distresses me beyond measure to see our ships constructed so as to impose upon them the most terrible penalties whenever their commanders dare, as dare they ever have, and dare they ever will, to close with their foe and try conclusions with him. Why, sir, it has been my painful duty over and over again to hear foreign officers entreat me to use all my influence against the adoption in their navy of ships with so little armored surface as ours. On one occasion the *Collingwood* herself was imposed upon them as a model to be imitated, and I was besought to give them a safer and better ship. 'How could I ever steam up to my enemy with any confidence,' said one of the officers concerned, 'with such a ship as that under my feet?'

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"Mr. White coolly tells us that the *Collingwood*, with five hundred tons of water logging her ends to a depth of seven or eight feet, will not be much worse off than a ship whose armored deck stands two and a half or three feet above the water's surface, and his reason is that even above this latter deck the water would flow in when the ship was driving ahead with an injured bow. Well, sir, I will only say that sailors of experience see a very great difference between the two cases, and I can but regard such theorizings as very unfortunate basis for the designs of her Majesty's ships.

"I have said that Mr. White's assumptions as to the immunity of the above-water compartments and coffer-dams from wide-spread injury by shell-fire rest upon no experimental data; I go on to say that such data as we have to my mind point very much the other way. The *Huascar* was not an unarmored vessel, and such shell as penetrated her had first to pass through some thin armor and wood backing; yet after the *Cochrane* and *Blanco Encaloda* had defeated her she presented internally abundant evidence of the general destruction which shell-fire produces. An officer of the *Cochrane*, who was the first person sent on board by the captors, in a letter to me written soon afterwards, said: 'It requires seeing to believe the destruction done. . . . We had to climb over heaps, table-high, of *débris* and dead and wounded. . . . We fired forty-five Palliser shell, and the engineers who were on board say that every shell, or nearly so, must have struck, and that every one that struck burst on board, doing awful destruction.'

"Speaking of the injury which the *Cochrane* received from a single shell of the *Huascar*, he said: 'It passed through the upper works at commander's cabin, breaking fore and aft bulkhead of cabins, breaking skylight above ward-room, thwartship bulkhead of wood, passed on, cut in two a 5-inch iron pillar, through a store-room, struck armor-plate, glanced off, passing through plating of embrasure closet at corner, finishing at after gun-port, and went overboard. This shell passed in at starboard part of stern and terminated at after battery port on port side, which is finished with the wide angle-iron, carrying out a part of the angle-iron in its flight.'

"This was a shell of moderate size, from a moderate gun, but it is obvious that it would have made short work of penetrating those very thin sheets of steel which constitute the compartments, coffer-dams, etc., upon the resistance of which, to my extreme surprise, those responsible for the power and safety of our fleets seem so ready to place their main dependence.

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"For resistance to rams and torpedoes, and for the limitation of the injuries to be effected by them, as much cellular subdivision as possible should be supplied; but, as against shot and shell, subdivision by their sheet-steel is no guarantee whatever of safety in any ship, least of all in line-of-battle ships, which must be prepared for fighting at close quarters.

"I must now ask for space to remark upon a few minor points in Mr. White's letter. He seems to consider that the scant armor of the *Admiral* class is somehow associated with the placing of the large, partly protected guns of these ships in separate positions, 'in order to reduce the risks of complete disablement of the principal armament by one or two lucky shots, which may happen when the heavy guns are concentrated on a single citadel or battery.' Suffice it to reply that in the proposed new designs of the Admiralty ships now before Parliament, which have almost equally scant partial belts of armor, the guns are nevertheless concentrated in a single battery.

"Again, Mr. White says the Admiralty have declined to adopt my advice to protect the *Admiral* class in certain unarmored parts with 3-inch plating, and declares that such plating would practically be no better defence against rapid-fire guns than existing thin sides; but has he forgotten the fact that my suggestion has been adopted in the new designs for the protection of the battery of 6-inch guns, although it is perversely withheld from those parts of the ship in which it might assist in some degree in prolonging the ship's ability to float and to resist capsizing forces?

"Mr. White makes one very singular statement. He takes exception to my claiming for the *Inflexible* type of ship, on account of their armored citadel, a much better chance of retaining stability in battle than the *Admiral* type possesses, because, he says, 'in both classes the armored portions require the assistance of the unarmored to secure such a range and amount of stability as shall effectually guarantee their security when damaged in action.' The fair inference to be drawn from this would be that where the principle long ago laid down by me, and supported by Mr. Barnaby in the words previously quoted, is once departed from, the danger must in all cases be so great as to exclude all distinctions of more or less risk. Mr. White can hardly mean this; but if he does not, then on what grounds are we told that a ship which has no armor at all left above water at an inclination say of six or eight degrees is no worse off than a ship which at those angles and at still greater ones has a water-tight citadel over one hundred feet long to help hold her up?

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"I am not at all disposed to enter into a discussion as to the relative stabilities of the English and French ships under various conditions. The French ships have armored belts two and a half to three feet above water from end to end. That fact, other things being presumed equal, gives them an immense advantage over our ships, which in battle trim have belts scarcely more than a foot wide above water, and for less than half their length. It is quite possible that the French constructors may have given their ships less initial stability than ours; from such information as I possess I believe they have; but in so far as the ship below the armor-deck, and the action of shot and shell upon that part of her, are concerned, whatever stability they start with in battle they will retain until their armor is pierced; whereas our ships may have a large proportion of theirs taken from them without their armor being pierced, and their armored decks are then less than half the height of those of the French ships above water.

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"I will add that I doubt if the French ships are dealt fairly by at Whitehall. I lately heard a good deal of the extreme taper of their armor-belts at the bow, and the *Amiral Duperré* was always quoted in instance of this. It is true that this ship's armor does taper from fifty-five centimetres amidships to twenty-five centimetres at the stem, but she stands almost alone among recent important ships in this respect, as the following figures will show:

Name of Ship.	Thickness of Armor Amidship.	Thickness of Armor at Bows.
	Centimetres.	Centimetres.
Amiral Baudin	55	40
Formidable	55	40
Hoche	45	40
Magenta	45	40
Marceau	45	40
Caiman	50	35
Fulminant	33	25
Furieuse	50	32
Indomptable	50	37
Requin	50	40
Terrible	50	37

"A friend writes me: 'Comparing the *Amiral Duperré* with the *Amiral Baudin, Devastation, Formidable*, and *Foudroyant*, which are ships of about her size, the following peculiarities are observable: The *Duperré* is about three feet narrower than the other ships mentioned, and has fully fifteen inches less metacentric height. She is also slightly deeper in proportion to her breadth than the other ships.'

"As narrowness, small metacentric height, and excessive depth all tend to reduce stability, it would appear that the Admiralty office has, as I supposed, been careful to select a vessel not unfavorable to their purpose. But however this may be, it is no business of mine to defend the French ships in the details of their stability, nor even to defend them at all; and, as a matter of fact, the French Admiralty, although stopping far short of ours, has in my opinion gone much too far in the direction of reducing the armored stability at considerable angles of inclination. But their falling into one error is no justification for our falling into a much greater one, and deliberately repeating it in every ship we lay down. In this connection I will only add that the experiments performed at our Admiralty on models must be viewed with great distrust for a reason not yet named. They deal only, so far as I am acquainted with them, with models set oscillating or rolling by waves or otherwise. But the danger thus dealt with is a secondary one; the primary one is that due to 'list' or prolonged inclination to one side. What sort of protection against the danger of capsizing from this cause can be possessed by a ship the entire armor on each side of which becomes immersed even in smooth water when the ship is inclined a couple of degrees only, and which then has no side left to immerse, save such as single shells can blow into holes ten by four feet?

"It is to be observed that although Mr. White does not venture to join the only other apologist for these deficiently armored ships in stating that India-rubber umbrella shot-stoppers are to be employed for their preservation in battle, he does go so far as to tell us that the spaces into which water would enter when the unarmored parts have been penetrated have been subdivided 'to facilitate the work of stopping temporarily shot-holes in the sides,' and I know independently that a good deal of reliance is placed at the Admiralty upon the presumed ability to stop such holes as they are made. But the whole thing is a delusion. The officer of the *Cochrane*, before quoted, said, 'I wish to state that shot-plugs are out of the question after or at such a fight. They are entirely useless. Not a hole was either round, square, or oval, but different shapes—ragged, jagged, and torn, the inside parts and half-inch plating being torn in ribbons; some of the holes inside are as large as four by three feet, and of all shapes. There are many shot-plugs on board here, all sizes, conical shapes and long, but they are of no use whatever.'

"Mr. White's letter invites many other comments, but I have said enough to show that it in no way changes my view of the question of armor-plated line-of-battle ships. In so far as it advocates a further abandonment of armor and a further resort to doubtful devices in lieu thereof, it is already answered by anticipation by the Admiralty itself. Until I wrote my recent letters to you, our Admiralty thought as Mr. White still thinks, and tended as he still tends. In the case of all our recent cruisers but two they had abolished side-armor altogether. To my public appeal for armor-belted cruisers they have, however, responded, and are about to order six of such ships. So far, so good. We ought to be grateful for this concession to a most reasonable demand. I wish these cruisers were to be faster, much faster, but in Admiralty matters the country must be thankful for small mercies.

"It only remains for me to note with satisfaction one or two of the points upon which Mr. White is in agreement with myself. He admits that it 'would certainly be advantageous' to carry out those experiments which I regard the Admiralty as afraid to make, *viz.*, experiments to test the effect of gun-fire upon the subdivided but unarmored parts of ships.

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"It may be taken for what it is worth, but I declare that the abandonment of armor has not at all been forced upon us by unavoidable circumstances, nor is it from any intrinsic necessity that we go on refusing to provide our ships with torpedo defence. On not immoderate dimensions, at not immoderate cost, ships might be built, still practically invulnerable to gun, ram, and torpedo alike, ships which could dispose of the *Admiral* class of ships more quickly and certainly than she could dispose of the feeblest antagonist that she is likely to encounter. But in order to produce such ships we must revive the now abandoned principle that armor, and armor alone can save from destruction those ships whose business it is to drive our future enemies from the European seas and lock them up in their own ports."

The Committee on Designs of 1872, previously alluded to, contained sixteen members, of whom six were naval officers. Two of those members, Admiral George Elliot, R.N., and Rear-admiral A. P. Ryder, R.N., dissented so far from their colleagues that they could not sign the report, and accordingly they submitted a very able minority report embodying their views.

The first of the "general principles" laid down in their report is as follows:

"That it is of the last importance that the modifications in existing types of men-of-war which the committee have been invited to suggest should be calculated not merely to effectually meet the necessities of naval warfare now and in the immediate future, but in full view of the probable necessities of naval warfare in the more remote future."

It must be a source of satisfaction to these gallant officers to observe in some designs of the present day a confirmation of their forecast in many particulars.

The following extracts from a letter bearing upon the present controversy, by Admiral Elliot, appeared in the *Times* (London) of April 24, 1885, and contain the pith of his oft-quoted arguments:

"My first impression on reading these letters in the *Times* is one of disappointment that the point at issue between these two experts has not been more closely confined to the comparative merits of side-armor *versus* cellular-deck armor, but that their attention has been directed to this feature of design only as connected with a particular type of ship, namely, the *Collingwood*, which vessel is a hybrid, or cross between the two systems of protection to buoyancy, and therefore not truly representative of either. Mr. White's defence of the unarmored ends of the *Collingwood* is so far unsatisfactory that it treats of a very imperfect development of the cellular-deck mode of protection, and therefore he is not an exponent of the real merits of this system.

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"I am quite aware that the main point at issue between these two distinguished naval architects has been more closely confined to the question of stability than to that of flotation as displayed in the design of the *Collingwood*, and in this scientific view of the case I do not feel competent to offer any opinion, except to point out that the cellular-deck principle *per se* does not involve any such danger as regards stability as is produced by the top weight of a central citadel. Mr. White acknowledges that this top weight will capsize his ship if deprived of the buoyancy afforded by the unarmored ends, and on this danger point Sir Edward Reed fixes his sharpest weapon of attack.

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"The great issue at stake is how the weights available for the protection of buoyancy and for gun defence are to be distributed to the best advantage for defensive purposes, and in order to discuss Sir Edward Reed's opinions in a concise form I will deal with the question solely as concerning the use of side-armor of less than twelve inches, beyond which limit of thickness I will, for the sake of argument, admit its practical advantages; and looking to the demand for increased speed and coal-carrying capacity, it does not appear probable that if combined with adequate gun protection, and if of sufficient depth, an all-round belt of thicker than ten inches can be carried by any vessels of war except those of much greater displacement than the *Collingwood* class. I feel justified, however, in discussing the question on this basis, because Sir Edward Reed includes in his category of approved armored ships our recent belted cruisers, having a narrow belt of ten inches maximum thickness, and takes credit for having induced the Admiralty to abandon their original intention of cellular-deck water-line protection in this class of war-ship in favor of this thin armor-belt.

"The relative value of these two systems of water-line protection, namely, an all-round belt *versus* a raft body, must not only be ruled by the displacement decided upon for each class of vessel, and by the power of the gun which has to be encountered, but by such tactical expedients as can be resorted to in battle, as being those best suited to the known offensive and defensive properties of the combatants.

"Looking at this disputed question entirely from the point of view of an artillerist and a practical seaman, I can perceive very great tactical advantages to be obtained by the adoption of the mode of protection proposed as a substitute for obsolete armor, and I view with much regret the one-sidedness of the conclusions arrived at by the opponents of this system, and the disparaging terms in which it is sought to turn it into ridicule, such as 'doubtful devices' and 'useless contrivances,' etc., because they indicate prejudice and a want of mature consideration of the incidents of naval battles. I cannot, also, help observing that while, on the one side, prophesying the most fatal consequences to ensue from what is called 'stripping ships of armor,' on the other side no admission is made of the disastrous results which must follow from placing reliance on such a delusive defensive agency as an armor-plate known to be penetrable by guns certain to be encountered; and in order to support this theory we are called upon to believe that gunners will be so excited in action or so unskilful that in no case will they hit the large object aimed at, namely, the water-line of an adversary passing even at close quarters on their beam, but I shall refer to this feature of assumed impunity hereafter.

"Sir Edward Reed's comparative remarks on the effect of shot-holes as between the two systems of defence are of the same one-sided character, notwithstanding the evidence of the fractured condition of armor-plates subjected to experimental firing; and it is almost apparent that in decrying the one mode of protection he has lost sight of the fact that a ten-inch armor-plate is all that will stand between the life and death of a ship—that is to say, between one well-directed shell and the magazines and boilers—which plate can be easily penetrated and smashed up by the guns which similar vessels will assuredly carry if so invited. Also, in referring to the baneful effects of raking fire and shell explosion inboard, the assumed inferiority is misplaced because one prominent advantage of the cellular-deck system is that by economizing weight at the water-line it enables the bow and stern to be armor-plated—a matter of the highest tactical importance as a defence against raking fire, which is unobtainable in a belted ship of the same displacement, at least without entailing a considerable reduction of the thickness of armor on the belt. This feature of end-on defence is not only an essential element of safety, but must prove most effective as enabling a combatant to close his adversary at an advantage, and enforce the bow-to-bow ram encounter, or compel him to resort to a stern fight, or otherwise to pass him at such close quarters as will insure direct hits and depressed fire at the water-line belt, and by these tactics the opportunities for riddling the raft body will be few and far between.

"I may also express the opinion that for repairing damages in a raft-bodied ship at the water-line far more efficacious means can be resorted to than the ordinary shot-plugs, and that the use of cork bags for closing shot-holes in the coffer-dam sides, if they are open at the top, is far from being an unreasonable or 'stupid contrivance,' as it is called, considering that, as a general rule, the perforations through thin plating would not be ragged or extensive. Sir Edward Reed's wise suggestion to make the outer skin of the coffer-dam of two-inch steel plates would render machine-gun fire of little avail. The injurious effects of shell fire would, I reckon, be far more fatal if the projectile exploded in passing through the ten-inch belt than if it burst at some distance inboard after penetrating thin plating. I think it will be admitted without dispute that this feature of design must be governed to a great extent by tactical considerations, the object sought for being to secure out of a given weight of steel the greatest amount of fighting vitality consistent with the power of manœuvring available between skilful antagonists. This view of the case is especially applicable to single actions at sea, when a clever tactician will select his mode of fighting according to the offensive and defensive properties known to be possessed by his opponent, and in this respect an armor-plated bow and stern will afford enormous advantages, both for attack and defence, if the plating is extended as high as the upper deck.

"In fleet actions the ram and torpedo will require more attention than the gun attack, and that feature of battle introduces another disputed point, namely, the limit of size of ship; but that question is outside the scope of the present discussion, and I shall conclude my arguments by a strong expression of opinion that, as gunpowder has so completely mastered the pretensions of outside armor protection, the direction in which prudence leans towards defensive properties in future designs for ships-of-war is that of deflection rather than of direct resistance, and that in this respect science has not reached its utmost limit of invention.

"The prevailing disposition to regulate the power of the gun by the size of the vessel is, I consider, a great mistake, seeing that the additional weight of a powerful gun is not inadmissible, even in such vessels as our belted cruisers, and looking to the strong inducement held out by the continued use of armor-plating, even of such moderate thickness as ten inches. In the splendid steamers purchased from the mercantile marine, which are being armed with light guns only, one 25-ton gun would greatly add to their fighting power, but the cause of this omission may probably be found in the answer to the question, Where are the guns?"

The following reply appeared in the *Times* (London) of May 1, 1885:

"Sir,—The letter of Admiral Sir George Elliot . . . deals ably and candidly with a subject of such fundamental importance to our navy that I venture to offer a few observations upon it.

"I am glad to see that the gallant admiral separates his case and the cellular or raft-deck system from any connection with the *Collingwood* or *Admiral* type of ship, but I regret that he has treated my criticisms of that kind of ship just as if I had applied them in the abstract to the system which he advocates. This is not fair either to the gallant officer himself or to me, as will presently appear.

"If Sir George Elliot will remove the cellular or raft-deck question completely away from the very unsatisfactory and unpleasant region of Admiralty practice, and let it be treated upon its merits, while I shall still have to respectfully submit to him some cautionary considerations, I shall also be prepared to make to him some very considerable concessions. One thing I should find it desirable to press upon him is the absolute necessity of giving closer attention to the provision of stability. He treats the subject mainly as a question of 'buoyancy,' and wisely so from his point of view; but 'stability,' or the power of resisting capsizing, comes first, and on this he declines to offer an opinion. Again, when the gallant officer speaks of a 'raft' deck, I would point out that this may be a very different thing from a cellular-deck. The characteristic of a raft is that it is usually formed of solid buoyant materials; you may make it of cellular steel if you please, but in that case wherever injury lets in water the steel so far ceases to be a raft, which helps to float its load, and becomes a weight to help sink it. Now, cells formed of thin steel do not upon the face of the matter appear to be safe materials for a raft which is to be subject to the multitudinous fire of small guns and the explosions of shells of all sizes. It needs a very skilful artificer to build a safe floating raft of thin steel for such a purpose, especially when regard is had to the dangers of raking fire, against which bow and stern armor would not sufficiently provide.

"Having expressed these cautions, I will go on to say that in my opinion the main idea of your gallant correspondent, which he has so long and so steadily developed, is nevertheless a sound one, and one which has a great future. I do not, of course, for a moment admit with him that the gun has yet mastered the armor. I believe the *Dreadnought*, though of old design, would still fight a good action against all ships now ready for sea, and have to fear only a very exceptional, and therefore either a very skilful or very fortunate, shot. The recent Admiralty ships, where they are armored, are practically proof against almost every gun afloat. Further, I have satisfied myself that if the existing restrictions imposed upon us by the absence of floating docks adapted to receive ships of great breadth were removed (these restrictions crippling us to a most unfortunate degree), and if certain professional conventionalities as to the forms of ships were set aside, it would be perfectly practicable to build war-ships no larger and no more costly than the *Inflexible*, with enough side-armor more than a yard (three feet) thick to preserve their stability, and at the same time made ram-proof and torpedo-proof. Meanwhile, of all the vulnerable objects afloat, the recent guns themselves, by reason of their absurdly long and slender barrels, left fully exposed to all fire, are among the most vulnerable.

"Still, the raft-deck system has a wide field before it, and I am quite prepared to admit that I believe in its practicability and in its sufficient security for certain classes of vessels if properly carried out. This it has not yet been in any single instance. Even in the case of the great Italian ships, as in our own, there are elements of weakness which would be fatal to the system in action, but which are *not* unavoidable. Allow me to assure Sir George Elliot that I have largely and closely studied this subject, and that my main objections to it are not objections of principle.

"If the raft-deck system is to be adopted, it must in my opinion be carried out in a much fuller and more satisfactory manner than hitherto, and with the aid of arrangements which I have for a long time past seen the necessity of, and been engaged upon.

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"To my mind the Admiralty, while protecting certain parts and contents of their largest ships from injury from shell fire, have made the fatal error of failing to protect the ship itself, which contains them all, from being too readily deprived of stability and made to capsize. The advocates of the alternative system must not repeat this error, or, if they do, they must not expect me to become their ally. On the other hand, if they will join me in despising what are merely specious elements of safety, and in demanding those which are real, if they will insist that our principal and most costly ships at least shall be so constructed as to keep afloat and upright for a reasonable length of time in battle, in spite of any form of attack, so as to give their gallant crews a fair chance of achieving their objects, they will not find me averse to any improvement whatever. When a suitable opportunity offers I shall be happy to show to Admiral Sir George Elliot that he has not been alone in seeking to develop the cellular or raft-deck system, and that it has, in fact, capabilities which possibly he himself may not yet have fully realized."

The same number of the *Times* contains a reply to Mr. Reed's letter of April 8, 1885, by Mr. White, mainly devoted to a refutation of certain charges of no interest to us, but containing the following paragraphs:

"I must refer to the passage in which Sir Edward Reed quotes a description of the damage done to the *Huascar* in her action with the two Chilian iron-clads.

"This description seems to me one of the best possible illustrations of a remark in my previous letter, that 'the *mitraille* which is driven back into a ship when armor is penetrated is probably as destructive as any kind of projectile can be.' Had the *Huascar* not had weak armor, but light sides only, the local injuries might have been less. The other case cited of a shell which entered the unarmored stern of the *Cochrane* shows how little damage may be done when a projectile passes through thin plating. At the bombardment of Alexandria there were many such examples on board our ships, although it must be frankly admitted that the engagement is no sufficient indication of what shell fire may do. A good deal of use has been made of the single case where a shell in bursting blew a hole ten by four feet in the thin side-plating of the *Superb*. The case was quite exceptional, whether it be compared with the other hits on the same ship or with the injuries done to the unarmored sides of other ships. Moreover, in that case exceptional injury is traceable to special structural arrangements at the embrasure near the battery port, where the shell struck. These cases do not prove that the light unarmored structures in the *Admiral* class are likely to be destroyed in such a rapid and wholesale manner as has been asserted. Nor, on the other hand, do they indicate conclusively what damage shell-fire may do in future actions. On these points, as I have before remarked, experiment might be made with advantage. But, on the other hand, there is good evidence that armor so thin as to be readily penetrable to many guns may be a serious danger, and that armor over the vital parts of ships should be strong if it is to be a real defence.

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"In matters of ship design the constructors of the navy are only the servants of the Board, and while they must take sole responsibility for professional work, the governing features in the designs are determined by higher authorities, among whom are officers of large experience, both as seamen and gunners. And it is certainly not the practice of the constructive department to intrude themselves or their advice into matters for which neither their training nor their experience fits them to give an opinion.

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"I make no attempt to be either a sailor or a gunner, but am content to seek information from the best authorities in both branches. As the result of this study of tactics and gunnery, I have been led to the belief that the sea-fights of the future are not likely to be settled altogether or chiefly by the effects of gun-fire. This is not quite the same thing as Sir Edward Reed attributes to me when he says that 'Mr. White thinks and speaks as if naval warfare henceforth were to be merely a matter of dodging, getting chance shots, and keeping out of an enemy's way.'

"Nor do I think that the designers of the Italian war-ships will indorse the description of their views and intentions, with which Sir Edward Reed has favored us in his letter and elsewhere. I have the honor of knowing his excellency Signor Brin (now Minister of Marine) and other members of the constructive corps of the Italian navy, and from their statements, including the powerful publications of Signor Brin, 'La Nostra Marina Militaire,' I have no hesitation in saying that in spending larger sums on single ships than have ever before been spent, the Italian authorities think, and are not alone in thinking, that they are producing the most powerful fighting ships afloat."

APPENDIX III.

RANGE OF GUNS.

From Report of U. S. Fortification Board.

GUNS AFLOAT RANGING POSSIBLY NINE TO TEN MILES.

Nation.	Ship.	Maximum Armor.	Draught.		Guns.	Calibre.
		Inches.	Feet.	In.	Number.	Inches.
England	Inflexible	24	25	4	4	16
France	Friedland	7⅞	29	4	2	10.6
"	Redoubtable	14	24	10	4	10.6
"	Duguesclin					
"	Bayard	9⅞	24	10	4	9.5
"	Turenne					
"	Vauban					
"	Fulminant	13	21	4	2	10.6
"	Tonnerre					
Italy	Duilio	21.7	28		4	17
"	Dandolo	21.7	28	9	4	17
Germany	Sachsen					
"	Baiern	17.25	19	8	4	10.2
"	Würtemberg					
"	Baden					
"	Wespe					
"	Viper					
"	Biene					
"	Mücke	8	10	2	1	12
"	Scorpion					
"	Basilisk					
"	Cameleon					
"	Crocodil					
Brazil	Riachuelo	11	20		4	9

Besides a large number on unarmored vessels and on armored vessels not yet completed.

GUNS AFLOAT RANGING POSSIBLY TEN MILES OR UPWARD.

Nation.	Ship.	Maximum Armor.	Draught.		Guns.	Calibre.
		Inches.	Feet.	In.	Number.	Inches.
England	Conqueror	12	24	0	2	12
"	Colossus	18	26	3	4	12
"	Edinburgh	18	26	3	4	12
France	Amiral Duperré	21.6	26	9	4	13.4
"	Dévastation and Foudroyant.	15	24	11	2 4	10.6 13.4
"	Terrible	19	24	7	2	16.5
"	Tonnant	17¾	16	9	2	13.4
"	Vengeur	13¾	16	9	2	13.4
Italy	Italia	18.9	30	3	4	17
Germany	Salamander					
"	Natter	8	10	2	1	12
"	Hummel					
China	Ting Yuen	14	20		4	12
"	Chen Yuen					